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Multi-Criteria Decision Making for Engine Component Supplier Selection Using Analytical Hierarchy Process in the Automotive Component Industry

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ABSTRACT

One of the automotive component industries engaged in rubber production of hose parts, damper parts, and anti-vibration parts for use in four-wheeled vehicles experienced problems with delays in damper part materials from Japanese suppliers, which disrupted the production process and shipping to customers. This study aimed to identify the factors causing the delay and find a solution to replace suppliers from imports to local. This study has adopted two methods, namely Fault Tree Analysis (FTA) which is used to determine component not on-time, while to find domestic suppliers (component localization) as a solution to improve the next process using the Analytical Hierarchy Process (AHP) method. This study has provided recommendations by analyzing four assessment criteria that have a weighting order from highest to lowest, namely price, quality, delivery, and service. The FTA method is very important in analyzing fault trees that can determine the main causal factors. The results of the overall assessment analysis through the AHP method related to the capabilities of the four suppliers show that supplier C produces a higher value than supplier D, supplier B and the lowest is supplier A. Thus, supplier C is the best and is selected as a supplier of damper part material for the RXD25N engine mounting project. The high priority assigned to price reflects the company's objective of localizing imported materials while maintaining competitive procurement costs and avoiding additional costs for customers.

1. INTRODUCTION

Raw material procurement is a strategic activity in supply chain management [1]. Asia is home to some of the largest automotive markets and leading global brands. In recent years, the Asian region has also actively promoted regional integration through various initiatives, such as cross-Asian trade agreements and the development of infrastructure projects [2]. In the automotive industry, the procurement of raw materials and components plays a crucial role because it directly impacts the quality and cost of the final product [3]. If the raw materials provided by the supplier are of poor quality, it will affect the quality of the finished products. The case studies occur when a company's raw material needs cannot be provided by its suppliers; this case will result in a mismatch in the delivery schedule, which may prevent the company from achieving its vision. One of the key factors for a company's success is the selection of suppliers [4]. Well-functioning supply chain integration can support companies to optimize on-time delivery, product quality, increase production capacity, and improve overall performance [5]. The manufacturing industry cannot operate without suppliers, as suppliers play a crucial role in supporting the production process for the company [6, 7]. Choosing the right supplier will determine the company's sustainability.

The procurement process plays a crucial role in supporting the daily operations of nearly all manufacturing and service companies worldwide [8]. Companies strive to find the most efficient delivery system because it directly impacts the profitability and competitiveness of the company and its entire supply chain. The smoothness of the delivery process ultimately depends on the accuracy of selecting the right supplier [9]. Procurement of goods and services is firts of the initial step in the procurement of a project, including the selection of project vendors [8]. Issues that arise during project execution, such as delays in supplying spare parts and the lack of qualified personnel for the project, can significantly affect the project's progress.

Effective vendor selection represents a crucial concern for many organizations. With the rapid advancement of marketization, the pool of potential vendors has expanded, and the criteria involved in selecting them have become increasingly diverse and complex [10]. Therefore, it is necessary to make the right decision in choosing a supplier that has competitive prices, good quality, and shipping. Good shipping will be supported by a good supply chain [11]. The procurement process needs to recognise and explore its position given a more strategic role in companies [12].

Purchasing managers need to conduct regular supplier performance assessments to retain suppliers that meet company requirements. The literature has long emphasized the importance of integrating various attributes, such as product price, product quality, services and on-time delivery, into the vendor evaluation process [13]. The increasingly strategic nature of supplier selection decisions is prompting organizations to review their procurement strategies and evaluation methods, given that the success of purchasing decisions depends heavily on selecting the right vendor. Quality is generally a crucial aspect for most manufacturers in the purchasing process. Furthermore, purchase price is also a crucial factor because it directly impacts product costs, although it does not fully reflect the full costs of receiving materials [14].

In the modern era, companies demand that suppliers are able to meet and maintain predetermined standards, including product quality, service, distribution, promotion, and partnership relations. However, without effective and ongoing supplier performance monitoring, companies cannot accurately evaluate whether existing suppliers are meeting organizational needs [15]. This research focuses on manufactured products in the automotive sector automotive component industry engaged in rubber that produces types of hose parts, damper parts and anti-vibration for use in four-wheeled vehicles with customers both domestically and abroad. The problem of delays in damper part materials on the RXD25N engine mounting project sent from Japan is the main problem. Delays in the delivery of raw materials are caused by various factors, including limited supplier production capacity, delays in raw material procurement, misaligned production schedules, and product quality issues. In choosing a local supplier, the main criteria are competitive prices, quality and on-time shipping times [16]. Therefore, companies are required not only to reduce delays in damper part materials but also to find superior local suppliers over foreign suppliers. The data report related to the assessment of price, quality and shipment criteria for 3 years as presented in Table 1.

Table 1. Assessment criteria from report data 2022-2024

Assessment Criteria	2022	2023	2024	Average Achievement per Year
Price (Price Fluctuation)	10%	8%	11%	9.6%
Quality (Claim Frequency)	7 times	6 times	4 times	6 times
Shipping (Frequency Delay)	6 times	8 times	12 times	9 times

Based on Table 1, price fluctuations indicate an unstable situation: 10% in 2022, decreasing to 8% in 2023, and then rising again to 11% in 2024, with an average of 9.6%. The frequency of quality-related claims has declined from 7 to 4 instances, yet it has not reached the company's "zero-claim" target. Conversely, delivery delays have increased over the past three years. This suggests that delivery punctuality is a primary issue that must be prioritized during the evaluation and selection of suppliers. Suppliers play a crucial role in the smooth operation of the supply chain. Selecting the right supplier can improve production efficiency while supporting company profitability. However, selecting the right business partner is no simple task, as companies must conduct comprehensive evaluations based on established criteria to select the best supplier [17]. Making decisions to choose requires an analysis tool that allows to solve complex problems. Gradually starting in 2023, for material needs that are still imported from China and Japan, the company will carry out a localization program, namely a program to fulfill material needs that are still imported, especially from Japan, to be met by local suppliers (Indonesia).

The problem experienced by the manufacturer is the import material localization program involves selecting local suppliers, where those who have been selected are able to carry out their obligations to provide the materials needed by the company. One of the materials that will be localized in the first stage is the damper part material on the RXD25N engine mounting part project, which has so far been ordered from Japan, so it is necessary to select a local supplier who can provide the damper part material at a cheaper price and the same quality as imports [18]. The current procedure for selecting local suppliers under the company's localization program tends to prioritize price; suppliers offering the lowest costs are chosen to provide materials. This approach is considered inefficient, as it risks leading to various issues, such as delivery delays or poor product quality. Consequently, it is necessary to re-evaluate and refine both the number of suppliers and the criteria used in the selection process [19].

The phenomenon of company problems related to the shipping of imported goods from Japan is delayed, the price increases every year, the quality of goods decreases, so that the company experiences delays in production. Therefore, the company will switch imported goods to local goods by choosing local suppliers who have worked together in the last 3 years. The company must choose and determine which local supplier is the most appropriate in terms of price, quality, shipping and service.

The right strategy in decision-making is the Analytical Hierarchy Process (AHP). However, in determining AHP, you must first know the Fault Tree Analysis (FTA) or fault tree or factors causing the problem [20]. FTA contributes to identifying causal relationships and the dominant factors that trigger supply delays, while AHP is used to determine the priority weights for supplier selection criteria based on aspects such as quality, price, delivery timeliness, capacity, and flexibility and to rank alternative suppliers [21]. The findings from the FTA serve as the foundation for formulating the evaluation criteria for the AHP, thereby integrating both methods into the decision-making process [22]. The gap in analysis with other studies in the same industry, namely automotive, is in the method used only uses AHP in selecting suppliers, but in analysing the causes of the problem, only using the Fishbone diagram [23]. The objective of this research is to analyze the causes of delays and to develop strategies for transitioning from imported suppliers to local suppliers.

2. LITERATURE REVIEW

AHP is one of the most commonly used multicriteria decision-making methods. This method is simple, easy to understand, and practical to apply. Its hierarchical structure, complemented by pairwise comparisons, allows it to handle complex problems, integrate quantitative and qualitative criteria, and support group decision-making [24]. The advantage of the AHP method lies in its ability to be based on experience, intuition, and empirical data, allowing it to

accommodate both qualitative and quantitative aspects in decision-making problems [25]. The literature review on AHP from previous research can be seen in Table 2.

Table 2. Literature review on Analytical Hierarchy Process (AHP)

Study	Method	Type	Industry	Price	Quality	Shipping	Service
Sirin et al. [26]	AHP	Technology	✓	✓		✓	
Haricha et al. [27]	AHP + CRNN	Automotive with AI	✓	✓	✓	✓	✓
Chafiq et al. [28]	AHP	Energy	✓			✓	✓
Štilić et al. [29]	AHP + MABAC	Transportation	✓	✓	✓	✓	✓
Jayant [13]	AHP	Automotive	✓	✓		✓	
Thavamony and Rajagopal [30]	AHP	Civil Infrastructure	✓	✓	✓	✓	✓
Utami and Novianti [31]	AHP + TOPSIS	Salt Industry	✓	✓	✓	✓	✓
This research	AHP + FTA	Automotive	✓	✓	✓	✓	✓

Based on Table 2 regarding previous research, the AHP has been widely utilised as a decision-making method. It is not only applicable to the automotive industry but can also be used in various other sectors. Several studies, such as the study [27] integrate AI (CRNN) for supplier performance prediction in the automotive industry with Industry 4.0 in technology applications AI. The research [29] combines AHP with MABAC for taxi service demand in the transportation industry. The research [13] relies solely on AHP without additional analysis to determine the root causes of issues in supplier selection. This study discusses the selection of local suppliers in the automotive industry using the FTA and AHP methods.

In contrast, this research focuses on supplier selection in the automotive industry, emphasising supplier localization to reduce dependence on imports. This research addresses a gap in the literature regarding supplier selection in the automotive industry by considering supply delay issues and supplier localisation as a strategic solution. Unlike previous studies that evaluate suppliers based solely on price, quality, and shipping, this study integrates the AHP with FTA to identify the root causes of supply delays and develop strategic solutions through supplier localisation. The combination of AHP and FTA for supplier selection is an approach that has not been widely applied in similar studies within the automotive industry.

3. METHODOLOGY

This research examines a system involving two workshops in the production and utilization cycle of a product. The first workshop provides a homogeneous product needed by the second workshop. The demand originating from the second workshop is assumed to be stable over time. The first workshop undertakes two main operations: manufacturing new products and refurbishing items returned by the second workshop. Repaired products are assumed to possess quality equivalent to that of new products. Items that can be restored are reused, while those beyond repair are disposed of as waste. The analytical process is structured using a hierarchical model comprising objectives, criteria, sub-criteria, and alternatives. According to the study [32], the comparisons within this framework serve to determine the weight of each criterion and to assess the relative performance of the alternatives against the specified criteria. Furthermore, the method evaluates the consistency of the judgments and provides corrective procedures if inconsistencies arise. AHP is a general measurement theory that relies on individual and group values and judgments, where these judgments are aggregated through a hierarchical structure to establish priorities. The main advantage of this hierarchical approach is its ability to comprehensively describe problems into basic components and their interrelationships in a detailed, structured and systematic manner, with a high degree of flexibility [33].

The AHP technique is a systematic and structured problem-solving procedure for representing various elements within a problem. AHP is based on three main principles: hierarchical framework construction, pairwise comparisons, and priority synthesis [34]. This method serves as an effective decision-making framework by streamlining and expediting the decision-making process. The supplier selection criteria that align with the company's needs can be determined using the AHP method. Supplier selection, supplier management, and purchasing policies are key elements in supply chain management. While previous research has generally focused on supplier selection using the AHP method, this study emphasizes supplier selection supported by supplier management and appropriate purchasing policies, while still utilizing the AHP approach.

Strategic supplier selection is a crucial procurement activity for many companies. Today, consumers demand high-quality products, more competitive prices, on-time delivery, and superior after-sales service. This puts significant pressure on companies to lower product and material costs without sacrificing quality or after-sales service. Achieving this goal begins with selecting the right supplier. Thus, the implementation of the correct Supplier Selection Process is crucial and contributes greatly to the success of supply chain [35]. The study selects the following 4 attributes or criteria for the supplier selection problem. In previous research, with the results of the research showed that the selection of automotive component suppliers the order of the results of the weighting of the most influential criteria to the least influential, namely price, quality, shipping and service. This research strategy in solving the problem is presented in Figure 1.

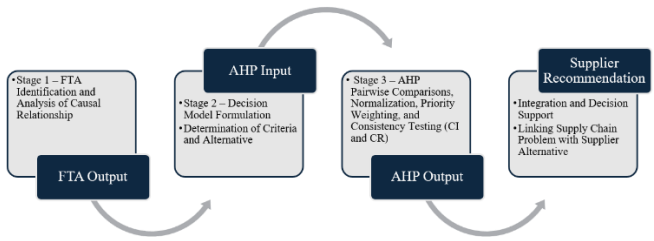

Figure 1. Research stages

Figure 2 illustrates a research framework that is interconnected, systematic, and mutually supportive, designed to facilitate objective supplier selection decisions. The proposed research framework integrates failure analysis and multi-criteria decision modeling to support engineering decisions in supplier localization. The framework consists of three interconnected stages. First, FTA is used to process supply chain problem data obtained from observations, interviews, and company records. This stage identifies the relationships between the main supply chain problems and their contributing factors, providing a structured diagnosis of supplier management weaknesses. Second, the identified problems provide the rationale for formulating a supplier localization decision. The AHP is then applied to evaluate four potential local suppliers using price, quality, delivery, and service criteria. Pairwise comparisons, priority weighting, and consistency testing are performed to determine the relative importance of each criterion and supplier alternative. Finally, the FTA findings and AHP ranking are integrated to provide a traceable decision-support framework. FTA explains why improvement is needed, while AHP determines which local supplier should be prioritized. This integration supports systematic engineering decision-making without introducing an artificial process control algorithm.

Data collection for this study is conducted in two stages. The first stage involves identifying supplier selection criteria through the development of a questionnaire, informed by discussions with managers possessing over 10 years of professional experience. The outcomes are used to define the criteria deemed essential for supplier selection decisions. The second stage entails distributing the questionnaire to expert staff with more than two years of work experience, including three members from the Procurement Department. The questionnaire data is then processed using AHP to determine the priority weight for each criterion, which serves as the basis for evaluating and selecting the optimal supplier. The source of data that will be used to process the data processing of this research presented in Table 3.

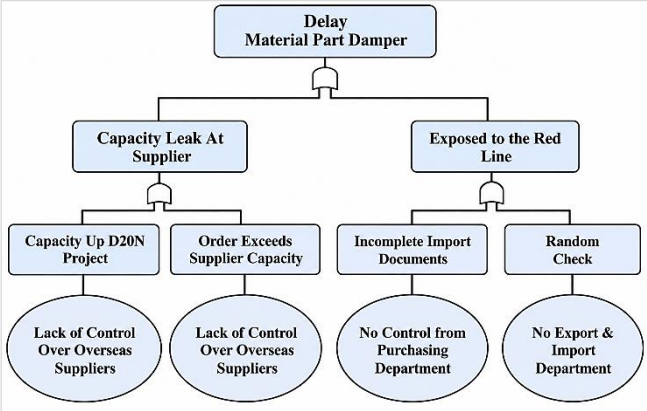

Figure 2. Fault Tree Analysis (FTA) material delay damper part

Table 3. Collection technique data

No.	Type Data	Collection Method Data	Source Data
1	Part damper price quote data	Observation	Purchasing
2	General data on price, quality and shipping	Observation	Purchasing
3	Data about supplier services	Interview	Purchasing

Based on Table 3, the data collection related to damper part price quote data, general data on price, quality and shipping using the observation method, while for data about supplier services, using interviews because detailed explanations are needed from stakeholders and purchasing. The way to conduct observations in this study is to observe reports on data on price offers for spare part dampers and general data reports on prices, quality, and shipping over a period of 3 years from 2022 to 2024.

4. RESULT AND DISCUSSION

4.1 Problem identification

The problem that occurs in the automotive component industry, namely the delay in damper part material, has been addressed in several stages. By conducting analysis and gradual repairs on each process flow, so as not to impact delays in shipping to customers. FTA is used to represent a physical system in a structured logic diagram and link the root causes of system failures. The analysis process is conducted based on established definitions [36]. Through FTA, critical components can be identified by examining the severity and frequency of various events [37]. FTA is a crucial analysis method in system safety engineering and is widely applied in various industrial sectors to assess and promote greater reliability and safety in complex systems. In practice, FTA analysis generally begins with the peak event, then traces the direct and indirect causes in a step-by-step manner from top to bottom. Next, the root cause of the accident is determined, while the logical connections between events are depicted in a fault tree structure. [38]. This FTA method will analyze the problem of damper part material delays, namely capacity leaks at suppliers and being hit by the red line. The research team analyzed it into derivative problems, namely increased capacity, orders exceeding supplier capacity, incomplete import documents, and random checking activities. The problems that arise in the error tree are obtained from data reports for 3 years from 2022 to 2024. The results of the FTA method that can be applied to analyze damper part material delays are presented in Figure 2.

Based on Figure 2, FTA is employed to identify the underlying supply chain problems, including weak control over overseas suppliers, limited control within the purchasing department, and issues in import-export management. These findings provide the basis for considering supplier localization as a strategic alternative to reduce dependence on international supply chains. AHP is applied to evaluate four potential local suppliers based on four criteria: price, quality, delivery, and services. The AHP results establish the priority ranking of local suppliers and support the selection of the most suitable alternative [39].

4.2 Proposed improvements

In this section, it will be discussed how to implement improvements by preparing all the necessities in the form of improvement proposals. The proposals that researchers submitted to the company are presented in Table 4.

Based on Table 4, it is recommended that the company localise suppliers for damper part materials. This aims to reduce the problem of delays in damper part materials, which can have an impact on delays in product shipping to customers.

Choose the best local supplier based on the criteria of cheaper prices, quality according to standards, on-time shipping and good service. The data taken in this study is data from observations regarding current price conditions, quality, shipping and service from suppliers in the period 2022-2024, which is presented in Table 5.

Table 4. The description of root causes and proposed improvements

No.	Root of the Problem	Problem Description	Proposed Improvements	Conclusion
1	Lack of control over overseas suppliers	Management does not pay much attention to supply chain management, prioritising price over other aspects that can harm the company.	Carried out a management review of imported parts so that a localisation study can be carried out.	Supplier Localization
2	No control from the purchasing department	Currently, the purchasing department only controls local suppliers, because the ratio of imported parts to local parts is very small.	Evaluation of imported part suppliers to be submitted to management for supplier localisation.	Supplier Localization
3	No export and Import department yet	The company does not have a special department to handle export and import activities, which results in the absence of special control over export and import activities in the event of random checks.	Add a dedicated PIC to handle export and import activities. Conducted a supplier localisation study so that there is no additional manpower.	No Export and Import department yet

Table 5. The price, quality, service and shipping report data recap 2022-2024

Supplier/Criteria	A	B	C	D
Price Fluctuation	6%	4%	2%	3%
Claim Frequency	5 times	4 times	1 times	7 times
Frequency Delay	4 times	6 times	2 times	8 times
Easy and Fast Services	57%	86%	43%	71%

Based on Table 5, the four local suppliers have varying research results, but the one with the fewest problems is Supplier C. After the data needed for this study is collected, the next step is to process the data. The data obtained will be processed using the AHP.

4.3 Improvement realization

This approach facilitates the prioritisation of multiple criteria through a pairwise comparison analysis of each criterion. There are four stages or principles in solving problems using the AHP method, namely as follows:

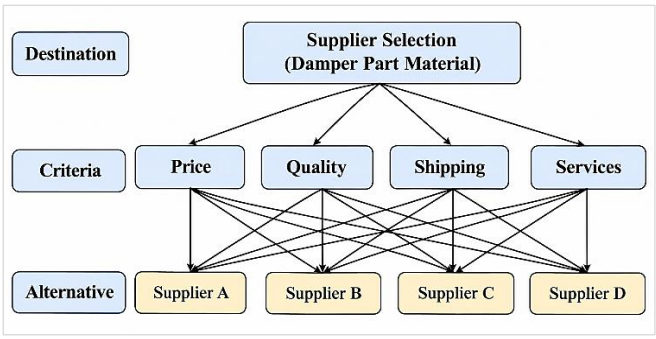

Figure 3. Hierarchical structure diagram of damper part material supplier selection

A. Defining the Problem and Setting Goals

If AHP is used to select alternatives or prioritise alternatives, then at this stage, alternative development is carried out. After the goal is obtained, the next step is to choose the criteria for selecting suppliers. Figure 3 shows the hierarchical structure in this study, as shown in the following Figure 3.

It is explained that the decision hierarchy for selecting a damper part material supplier carried out by the automotive component industry has three different levels. The top level explains the overall decision, namely, choosing the best supplier. The middle level in the hierarchy explains the factors or criteria that are considered, namely: price, quality, service and shipping owned by the supplier. The lowest level of the decision hierarchy shows the alternatives, namely supplier A until supplier D.

B. Compiling the Problem Hierarchy Structure

The role of the AHP is to provide cardinal information regarding criteria preferences, derived through a pairwise comparison technique. The foundation for constructing a pairwise comparison matrix in the AHP method lies in assessing the relative importance between two criteria or alternatives, based on the decision-making objective. This assessment utilizes the Saaty 1–9 scale, ranging from "equal importance" to "absolute importance." The matrix can be constructed using expert judgment to determine the relative weights of the criteria, as well as actual company data such as purchase price, frequency of quality-related claims, and delivery delays to compare alternative suppliers [40]. The next step we take is to start calculating the evaluation for the price criteria. To streamline the calculation of the pairwise comparison matrix values, we change them into decimal form, then we add up, so that the matrix results are obtained as in Table 6.

Table 6. The results of summing each column for price criteria

Supplier/Price	A	B	C	D
A	1	0.200	0.111	0.143
B	5	1	0.2	0.333
C	9	5	1	3
D	7	3	0.333	1
Total	22	9.2	1.644	4.476

Table 7. Normalized results for price criteria

Supplier/Price	A	B	C	D
A	0.045	0.022	0.068	0.032
B	0.227	0.109	0.122	0.074
C	0.409	0.543	0.608	0.670
D	0.318	0.326	0.203	0.223

We have to normalise the numbers in the matrix table by

dividing them by the number of numbers in each column to produce numbers like those in Table 7.

C. Determine Priorities

When the hierarchical structure has been established, each criterion needs to be assessed through pairwise comparisons to determine the relative importance of each criterion and the weight of each towards the overall objective [41]. The pairwise comparison process represents a key element in AHP, where decision makers assess two alternatives simultaneously using a comparative scale. The calculation and analysis examples in this study use price criteria to provide an overview of the calculation and analysis methods. The results of this comparison are presented in Table 8.

Table 8. Pairwise comparison matrix for price criteria

Supplier/Price	A	B	C	D
A	1	1/5	1/9	1/7
B	-	1	1/5	1/3
C	-	-	1	3
D	-	-	-	1

Based on the data in Table 8, supplier A has a higher price increase than suppliers B, C and D. So supplier B has a lower price increase than supplier A, supplier C has a lower absolute price increase than supplier A and lower than supplier B and slightly lower than supplier D, supplier D has a very low price increase compared to supplier A and slightly lower than supplier B. Then based on the assessment example, we can arrange the scale of importance using the priority scale of paired comparisons made by Saaty. The scale used includes a value of 1 which indicates the same level of importance, a value of 3 for criteria that are slightly more important, a value of 5 which indicates more important, a value of 7 which indicates much more important, a value of 9 which represents the absolute level of importance, and values 2, 4, 6, and 8 as intermediate values. To complete the pairwise comparison matrix above, we can place the number 1 diagonally from along the main diagonal from the upper-left to the lower-right, which represents a value of 1 since each element is compared with itself and considered equally important. Then to complete this Table, the results and understanding can be described that supplier B has a price difference 5 times lower than supplier A, so it can be concluded that the price increase of supplier A is one-fifth of supplier B. Supplier C has a price difference 9 times lower than supplier A, so it can be concluded that the price increase of supplier A is one-ninth of supplier C. Supplier D has a price increase 7 times lower than supplier A, so it can be concluded that the price increase of supplier A is one-seventh of supplier D. So the results of the new pairwise comparison matrix are obtained as in Table 9.

Table 9. Pairwise comparison matrix for price criteria

Supplier/Price	A	B	C	D
A	1	1/5	1/9	1/7
B	5	1	1/5	1/3
C	9	5	1	3
D	7	3	1/3	1

The third step at this stage is to determine the priority scale (weight) of the price criteria for the four damper part material supplier companies, and from the Table above, the average value of the rows of the pairwise comparison matrix is obtained as in Table 10 as follows.

Table 10. Evaluation factors (weights) for price criteria

Evaluation Factors for Price Criteria	
Supp. A	(0.045 + 0.022 + 0.068 + 0.032)/4 = 0.042
Supp. B	(0.227 + 0.109 + 0.122 + 0.074)/4 = 0.133
Supp. C	(0.409 + 0.543 + 0.608 + 0.670)/4 = 0.558
Supp. D	(0.318 + 0.326 + 0.203 + 0.223)/4 = 0.268

Based on Table 10, it can be seen that the evaluation factor for supplier A is 0.042, for supplier B is 0.133, for supplier C is 0.558, and for supplier D is 0.268. Thus, supplier C has the best score for the price criteria. However, before we determine the value of the evaluation factor as the basis for our assessment later, it is necessary to determine first whether the pairwise comparisons carried out are consistent enough or not by determining the Consistency Ratio (CR).

D. Determining the Consistency Ratio

The CR indicates the level of consistency of the decision maker in making pairwise comparisons, which ultimately indicates the quality of our decisions or choices. A large CR value indicates a less consistent comparison, while a lower CR value indicates a more consistent comparison. According to Saaty, the acceptable threshold is set at 0.10. When the CR is higher than this value, the reliability of the judgments may be doubted. The decision-maker revises these judgements until he/she achieve a CR smaller than 0.10 s [42]. The calculation of the CR begins with determining the Weighted Sum Vector, as presented in Table 11.

Table 11. Weighted sum vector for price criteria

Weighted Sum Vector for Price Criteria	
A	(0.042*1) + (0.133*0.2) + (0.558*0.111) + (0.268*0.143) = 0.168
B	(0.042*5) + (0.133*1) + (0.558*0,2) + (0.268*0.333) = 0.542
C	(0.042*9) + (0.133*5) + (0.558*1) + (0.268*3) = 2.401
D	(0.042*7) + (0.133*3) + (0.558*0.333) + (0.268*1) = 1.144

This can be done by multiplying the evaluation factor number for the first damper part material supplier, namely supplier A, by the first column of the initial pairwise comparison matrix. Then, multiply the evaluation factor for the second supplier (supplier B) by the second column, then the evaluation factor for the third supplier (supplier C) by the third column and finally the evaluation factor for the fourth supplier (supplier D) by the fourth column of the pairwise comparison matrix. The next stage is to calculate the Consistency Vector, which presented in Table 12. This can be determined weighted sum vector by the evaluation factor value that has been obtained previously.

Table 12. Consistency vector for criteria

Consistency Vector for Price Criteria	
Supplier A	0.168/0.042 = 4.043
Supplier B	0.542/0.133 = 4.076
Supplier C	2.401/0.558 = 4.304
Supplier D	1.144/0.268 = 4.276

After finding the consistency vector, the final consistency ratio can only be calculated after determining lambda (λ) and the Consistency Index (CI). The lambda value is usually the

average value of the consistency vector. Mathematically, the CI is obtained using the following formula:

$$CI = \frac{(\lambda - n)}{(n-1)}$$

Where n is the number of items or systems, or in this case, the number of suppliers being compared. In this case, n = 4, because four different suppliers are being compared. The calculation results are as follows:

$$\lambda \text{ (price)} = \frac{(4.043 + 4.076 + 4.304 + 4.276)}{4} = 4.175$$
$$\lambda \text{ (quality)} = \frac{16.696}{4} = 4.174$$
$$\lambda \text{ (shipping)} = \frac{16.836}{4} = 4.209$$
$$\lambda \text{ (services)} = \frac{16.340}{4} = 4.085$$

so that we get:

$$CI \text{ (price)} = \frac{\lambda - n}{n-1} = \frac{4.175-4}{4-1} = 0.058$$
$$CI \text{ (quality)} = \frac{\lambda - n}{n-1} = \frac{4.174-4}{4-1} = 0.058$$
$$CI \text{ (shipping)} = \frac{\lambda - n}{n-1} = \frac{4.209-4}{4-1} = 0.070$$
$$CI \text{ (services)} = \frac{\lambda - n}{n-1} = \frac{4.085-4}{4-1} = 0.028$$

The final step in the AHP procedure involves calculating the CR, which is obtained the RI value is determined based on the Random Index table. The Random Index is a parameter that depends directly on the number of alternatives or elements being evaluated. The RI values used in this study [8]. Mathematically, the CR is determined using the following equation, so the CR for each criteria is as follows:

$$CR \text{ (price)} = \frac{CI}{RI} = \frac{0.058}{0.90} = 0.065$$
$$CR \text{ (quality)} = \frac{CI}{RI} = \frac{0.058}{0.90} = 0.064$$
$$CR \text{ (shipping)} = \frac{CI}{RI} = \frac{0.070}{0.90} = 0.077$$
$$CR \text{ (services)} = \frac{CI}{RI} = \frac{0.028}{0.90} = 0.031$$

If the CR value is below 0.1, the pairwise comparison in the criteria matrix is considered consistent. Conversely, when the CR value exceeds 0.1, the matrix is regarded as inconsistent. In cases of inconsistency, the values assigned in the pairwise comparison matrix-both for criteria and alternatives must be reassessed and recalculated. Based on the computations performed using Expert Choice 11 software, the priority ranking of the normalized weights for each alternative is illustrated in Figure 4.

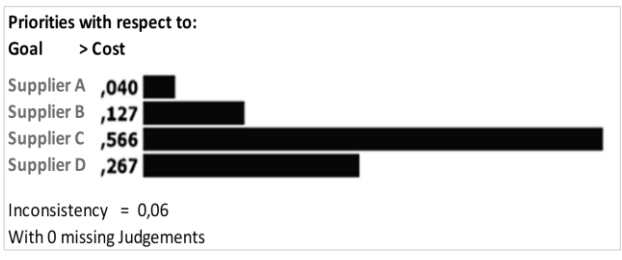

Figure 4. Normalisation of pairwise comparison of price criteria

After verifying the results using the calculation of Expert Choice 11 Software and MS Excel 2016, the result of the CR is 0.06, and this value is acceptable. For the alternative price criteria above, it has the same weight value of 1,000 between the calculation of the expert choice 11 software and MS Excel 2016. From the calculation results, it can be seen that supplier C has a value of 1.95 and is the alternative weight value on the highest price criteria. Furthermore, the same calculation method is used to determine the evaluation score for each supplier based on relevant criteria that are considered in determining the decision to choose the supplier of damper part material to be selected. And based on the results of the pairwise comparison carried out by the calculation analysis, the final results of all criteria are obtained as presented in Table 13.

Table 13. Supplier criteria evaluation scores

Supplier/Criteria	Evaluation Factors			
	A	B	C	D
Price	0.042	0.133	0.558	0.268
Quality	0.101	0.208	0.643	0.048
Shipping	0.227	0.097	0.632	0.044
Services	0.051	0.576	0.117	0.286
Total	0.421	1.014	1.950	0.646

Based on Table 13, Supplier C holds the highest values for the criteria of price (0.558), quality (0.643), and delivery (0.632), with a total score of 1.950. Meanwhile, Supplier B excels in the service criterion (0.576). These results indicate that Supplier C possesses advantages across three key aspects, making it the most promising alternative to prioritize in the supplier selection process. The lambda values, CI and CR of each criterion are presented in Table 14.

Table 14. Lambda value, CI and CR of each criterion

Value	Criteria			
	Price	Quality	Shipping	Services
Lambda (λ)	4.175	4.174	4.209	4.085
Consistency index (CI)	0.058	0.058	0.070	0.028
Consistency Ratio (CR)	0.065	0.064	0.077	0.031

After the evaluation value of all criteria is known, the stage for selecting a supplier who will supply damper part materials can be done by multiplying the total evaluation value by the weight of each criterion. The weights 0.529 (price), 0.315 (quality), 0.105 (delivery), and 0.051 (service) were derived from the calculation of criterion weights using the AHP method via the Expert Choice 11 software. The results of the multiplication are presented in Table 15.

Table 15. Results of multiplication of evaluation values with criteria weight values

Criteria	Weight	Supplier			
		A	B	C	D
Price	0.529	0.022	0.070	0.295	0.142
Quality	0.315	0.032	0.066	0.202	0.015
Shipping	0.105	0.024	0.010	0.066	0.005
Services	0.051	0.003	0.029	0.006	0.015
Total		0.080	0.175	0.570	0.176

Based on Table 15, it can be seen that the total evaluation value multiplied by the weight shows a value for supplier A of

0.080, for supplier B of 0.175, for supplier C of 0.570 and supplier D of 0.176. So it can be concluded that supplier C is declared to have passed to be selected as a supplier of damper part material because it has the highest value of 0.570 or around 57%. From the results of the AHP analysis, the most influential criteria in selecting suppliers in the automotive component industry are price criteria. The price criterion is assigned the highest weight of 0.529 because the company is currently implementing a supplier localization program for damper components. Under these circumstances, the company must ensure that the transition from imported to local suppliers does not lead to an increase in procurement costs, which could otherwise affect the product price for customers.

The high price-weight value in selecting suppliers shows that the automotive component industry prioritises price in selecting suppliers. This is necessary to ensure that the localisation program does not incur additional costs for customers. If there is no impact cost on customers, localisation is unlikely to be possible. Price criteria also have a fairly important role because the purchase of raw materials represents a fairly large portion of the sales value of its finished products. With cheaper raw material prices, it is hoped that the company can reduce raw material costs so that it can increase profits. In the overall price criteria, suppliers with the best price criteria in sequence are supplier C with a weight value of 0.295.

Quality criteria occupy the second position in the supplier selection process. This is due to the demand that raw materials supplied by local suppliers must have the same quality as imported raw materials, considering that good quality raw materials will have a positive impact on the quality of the final product, while the use of poor quality raw materials can reduce the quality of the finished product. Based on the evaluation of the overall quality criteria, supplier C is ranked first with a weight of 0.202, followed by supplier B as the second rank with a weight of 0.066, supplier A is ranked third with a weight of 0.032, and supplier D as the last priority with a weight of 0.015.

Shipping criteria are third in supplier selection, in the overall shipping criteria, Supplier C attains the top position with a weight of 0.066. Service criteria are fourth in supplier selection, service criteria are the last criteria position because local suppliers will be easier to contact and responsive than imported suppliers, because there is often poor communication with imported suppliers.

Overall service criteria, supplier B ranks highest with a weight of 0.029, followed by supplier D in second place with a weight of 0.015, supplier C in third place with a weight of 0.006, and supplier A as the last rank with a weight of 0.003. In general, the evaluation results based on all criteria show that supplier C is the best choice with a total weight of 0.570. The next rank is occupied by supplier D with a weight of 0.176, followed by supplier B with a weight of 0.175, and finally supplier A with a weight of 0.080. The findings from the comparative evaluation of material suppliers for the damper parts are presented in Table 16.

The final results of the selection show that overall, the best supplier that will be selected by the automotive component industry to be used as a supplier of damper part material is Supplier C, because overall it has the highest value compared to the other three suppliers. However, these results do not imply that Supplier C excels in all operational aspects. Supplier C's service performance stands at 43% compared to 86% for Supplier B suggesting potential challenges regarding ease of communication and responsiveness. In procurement activities, this could affect the speed of problem resolution, the coordination of order changes, the handling of complaints, and the follow-up process in the event of supply disruptions. Consequently, the company should continue to conduct periodic service evaluations, establish standards for supplier response times, and consider Supplier B as an alternative or backup supplier, should the need arise. The following is a description of the positioning of each supplier, which is presented in Figure 5.

Table 16. Comparative results of damper part material supplier selection

Sp.	Price	Quality	Shipping	Services	Total
A	0.022	0.032	0.024	0.142	21.9%
B	0.070	0.066	0.010	0.029	17.5%
C	0.295	0.202	0.066	0.006	57.0%
D	0.142	0.015	0.005	0.015	17.6%

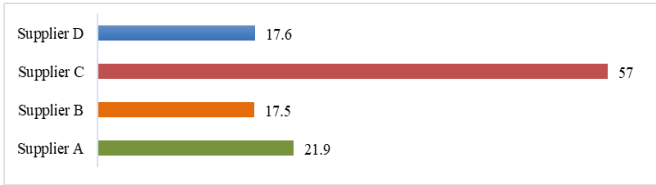

Figure 5. Final result of damper part material supplier selection (%)

4.4 Research implications

The findings of this study have several theoretical and practical implications for the automotive component industry, particularly in supplier selection and supply chain management.

A. Theoretical Implications

This research contributes to supplier selection by demonstrating the effectiveness of the AHP in evaluating multiple criteria, such as price, quality, shipping, and service. The study confirms that AHP is a structured and reliable decision-making tool that can simplify complex supplier evaluation problems. The integration FTA with AHP in supplier selection offers a novel approach to identifying the root causes of supplier-related delays and improving decision-making strategies. The results provide empirical support for the theory that local supplier selection can enhance production efficiency and reduce operational risks associated with international supply chains.

B. Practical Implications

The study highlights the need for continuous monitoring and evaluation of suppliers. Companies should establish a systematic assessment process to ensure suppliers maintain performance levels in terms of quality, shipping reliability, and service responsiveness. The findings support the argument that localising suppliers can mitigate supply chain disruptions. Firms operating in industries that rely on international suppliers may benefit from considering domestic alternatives to reduce dependency and enhance supply chain resilience. By demonstrating the weight and importance of different selection criteria, the study provides insights for procurement managers on prioritising supplier attributes that align with long-term

business goals. This approach enables companies to achieve cost efficiency without compromising quality or service reliability.

C. Managerial Implications

The influence of the results of this study is force on the company's management in general can increase significant profits. The transfer of suppliers from import to local will reduce the cost of import tax expenditures, and the quality of the material will be maintained because it saves time and faster shipping times. Economically, it can have an impact on saving supply chain costs, and the selection of local suppliers will also improve the performance of local companies to continue to exist in their operations. Socially, it can affect good relations with local companies, smooth communication and provide additional work for local companies. This research is more advanced and novel because in supplier selection from import to local using FTA method, so causal factor can be known by experienced factor analysis. Then in supplier selection improvement action using AHP method, so that price, quality, shipping and service variables from four suppliers can be determined effectively.

5. CONCLUSIONS

This study found that the selection process was carried out on four prospective suppliers, by analysing four assessment criteria that have a weighting order from highest to lowest, namely price, quality, shipping and service. The results of the analysis of the overall assessment of the capabilities of the four suppliers showed that supplier C produced the highest value of 0.570, supplier D was 0.176, then supplier B was 0.175, and the lowest was supplier A with a value of 0.080. Thus, supplier C is the best and is selected as a supplier of damper part material for the RXD25N engine mount project, so that it can have a significant influence on production efficiency and product quality. The high priority assigned to price reflects the company's objective of localizing imported materials while maintaining competitive procurement costs and avoiding additional costs for customers.

This study is limited in its scope, focusing on a single automotive component manufacturer, one specific type of component damper materials for the RXD25N engine installation project and four potential suppliers. Consequently, the findings cannot be directly generalized to the entire automotive component industry, as procurement characteristics, component types, quality requirements, and supply chain conditions vary from one company to another. Nevertheless, the integrated FTA and AHP approach have the potential to be applied to manufacturing firms facing challenges such as supply delays, reliance on imported suppliers, or the need for component localization.

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