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Journal of Optimization System and Ergonomy Implementation

| ISSN (Print) 2622-528X | ISSN (Online) 2598-5795 |

Choose one article category : Engineering Management and Industrial Optimization

Analysis of Supplier Selection of Steel Plate Raw Materials on Railways using Analytical Hierarchy Process (AHP) and Additive Ratio Assessment (ARAS) Methods at PT XYZ

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ARTICLE INFORMATION

Article history:
Received: January 27, 25
Revised: -
Accepted: June 04, 25

Keywords:
AHP
ARAS
Priority value
Business strategy

ABSTRACT

Companies need to develop a good business strategy in order to compete, including in choosing quality raw materials from the best suppliers. This research aims to select the best steel plate raw material supplier at company XYZ by using the Analytical Hierarchy Process (AHP) and Additive Ratio Assessment (ARAS) methods. This research involves the process of primary and secondary data collection which includes identifying supplier selection criteria, collecting data for each criterion, and collecting performance data from suppliers. The results showed that the order of the best steel plate raw material suppliers at company XYZ with the largest value was ranked 1st supplier company Steel Kras with a K value of 0,195207; ranked 2nd supplier company Jaraindo with a K value of 0,137696; ranked 3rd supplier company Capris with a K value of 0,135158; ranked 4th supplier company Kamaseta with a K value of 0,116481; ranked 5th supplier company Wima Indo with a K value of 0,106039 and ranked 6th supplier company Cenia Mandiri with a K value of 0,084586. Based on the AHP and ARAS methods, the relative weight of each criterion has been calculated, which helps in evaluating the best or potential suppliers to choose from. In addition, the ranking of suppliers is also determined based on the resulting priority value.

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http://dx.doi.org/10.30988/xxxx.xxxx.xxxx

INTRODUCTION

Companies need to develop a good business strategy in order to compete, including in choosing quality raw materials from the best suppliers [1]. In addition to quality products, consumers also demand good service and timely delivery, so suppliers play an important role in determining product quality and smooth production [2]. Company XYZ is a railroad manufacturing company. The company faces problems in selecting steel plate suppliers for its production process. Suppliers often send raw materials that do not meet the desired specifications and quality, while the company expects low prices but still quality. This problem is an obstacle in choosing the right supplier and has the potential to hamper the production process.

Derived from these problems, the company needs a method to choose the best steel plate raw material supplier so that the company can meet customer demand appropriately and increase its competitiveness in train production. To solve these problems, researchers used the AHP (Analytical Hierarchy Process) and ARAS (Additive Ratio Assessment) methods [3]. The AHP (Analytical Hierarchy Process) method has the advantage that it can be done in a hierarchy (order of levels) from the weighting results on each criterion so that it is easily understood by several people who want to make decisions [4]. However, the AHP (Analytical Hierarchy Process) method has a weakness in making uncertain decisions to give values to the number of criteria with pairwise comparisons. The best selection is of course done [5].

Implementing a decision support system by applying the ARAS (Additive Ratio Assessment) method because this method is used for ranking so that the problem is more focused and minimizes uncertainty [6]. AHP (Analytical Hierarchy Process) method applies the weighting results of each criterion then proceeds with the ARAS (Additive Ratio Assessment) method in order to produce an assessment of supplier performance in the form of more complex rankings based on predetermined criteria so as to produce more accurate decisions in selecting the best supplier at company XYZ [7]. Research is expected to provide input in the problem of selecting the best steel plate raw material supplier for company XYZ and can improve the quality of the final product. In addition, this research can also be an input for other companies that have similar needs in selecting raw material suppliers.

Supply Chain

Supply chain is a network of several companies that work together to create and deliver products to consumers [8]. In the supply chain there are 3 (three) kinds of flow, as in Figure 1 [9].

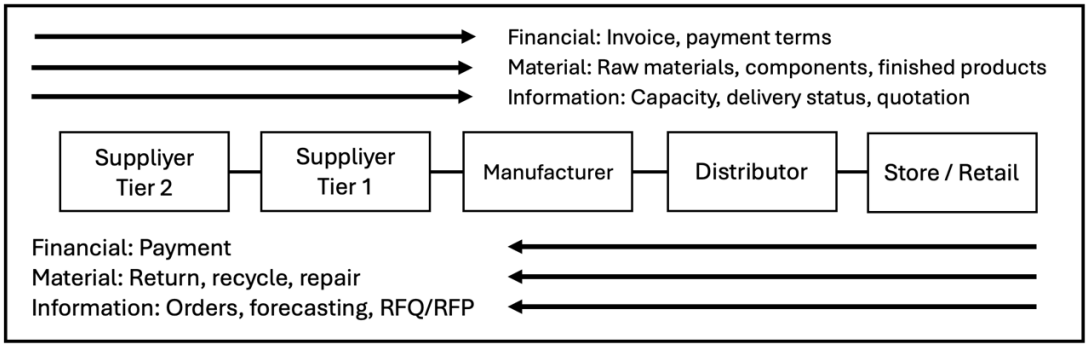

Figure 1. Implications of 3 Types of Managed Flows and Supply chain Models

Support the smooth supply chain, it is necessary to have smoothness between the existing aspects, one of which is the supplier. Supplier can be interpreted as a company or individual that can provide the needs of raw materials and goods needed by companies and competitors to produce certain materials [10].

Table 1. Supplier Selection/Evaluation Criteria According to Dickson

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Criteria	Score
Quality	3.5
Delivery	3.4
Performance history	3.0
Price	2.8
Repair service	2.2

Source: Pujawan, 2017

Metode *Analytical Hierarcy Process (AHP)*

Hierarchy Process (AHP) is a decision-making method with several criteria and provides a ranking or ranking of available alternatives [11]. Testing the consistency of the pairwise comparison matrix between criteria can be done with the following steps:

1. Calculate the weighted sum matrix B by multiplying the pairwise comparison matrix A with the criteria weight matrix W.
   $B = b_j$ with $b_j = {}_{j=1}^{n}a_{hj}w_{j,}$h= 1,2,…n ..... (1)
2. Divide all elements of the weighted sum matrix by the elements of the criteria matrix. C = cj with cj= $\underline{bj}$, j = 1,2 …, n ..... (2)
3. Calculating λ max. λ max is the largest eigenvalue of the pairwise comparison matrix.
   λ maks = $\frac{1}{n}{}_{j}^{n}C_j$ ..... (3)
4. Determine the consistency index
   CI= λ maks-n ..... (4)
   With n being the number of criteria being compared [4].
5. Calculating the consistency ratio
   CR = $\underline{CI}$ .....(5)
   RI

Metode *Additive Ratio Assessment (ARAS)*

The Additive Ratio Assessment (ARAS) method is a multi-criteria decision-making method or existing criteria based on the concept of ranking using utility degree, namely by comparing the overall index value of each alternative to the overall index value of the optimal alternative [12], [13]. The steps in performing the ranking process using the ARAS (Additive Ratio Assessment) method are as follows [14].

1. Formation of Decision Making Matrik.

$$X = \begin{bmatrix} X01 & X0j & \cdots & X0n \\ Xi1 & Xij & \cdots & Xin \\ \vdots & \vdots & \ddots & \vdots \\ Xn1 & Xmj & \cdots & Xmn \end{bmatrix} \quad \text{..... (6)}$$

2. Normalizing the decision matrix for all criteria.
   $\overline{X_{ij}} = \frac{X_{ij}}{\sum_{1}^{m=0}X_{ij}}$ ..... (7)
3. Determine the weights that have been normalized.
   D = [dij] mXn = X̄ ij.wj ..... (8)
4. Determine the value of the optimization function (Si)
   $Si = \sum_{j=1}^{n} dij$: (i=1,2,....m; j=1,2,.....n) ..... (9)
5. Determine the highest ranking level of the alternatives (*utility degree*)
   $Ki = \frac{Si}{So}$ ..... (10)

RESEARCH METHOD

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Solve a problem that occurs in research, problem solving steps are made [15]. The steps in problem solving (flowchart) can be seen in the figure below:

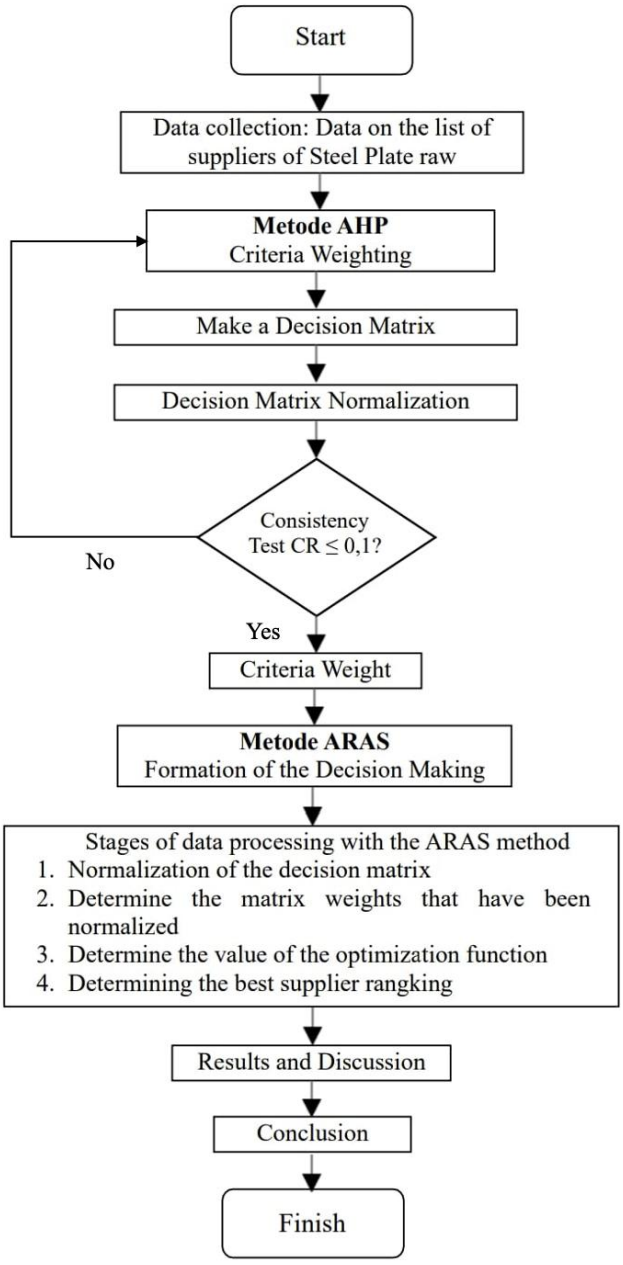

Figure 2. Problem solving steps

Data collection is done in several ways, including interviews with 7 company workers, namely in the Supply Chain Manager and Purchaser sections. As well as distributing questionnaires on the level of importance (weight) of criteria and supplier assessment questionnaires filled out by 1 part of the Supply Chain Manager and 6 people from the Purchaser. After collecting the data, the next step is to analyze the data, so that the problems faced can be resolved. The data processing technique used in this study is divided into two stages, namely using the AHP (Analitycal Hierarchy Process) method which is used to weight the criteria based on the eigenvalue and calculate the consistency ratio (CR) which is used to state the consistency of the results of the pairwise comparison matrix value of the criteria and the ARAS (Additive Ratio Assessment) method which is used for ranking alternatives based

on assessment data and weighting criteria that have been obtained from the previous AHP method [16].

RESULT AND DISCUSSION

In this study, the data used was obtained through interviews and distributing questionnaires conducted at company XYZ. There are 2 questionnaires distributed. The first questionnaire is used to determine the level of importance (weight) of the criteria. While the second questionnaire is used for supplier assessment [17].

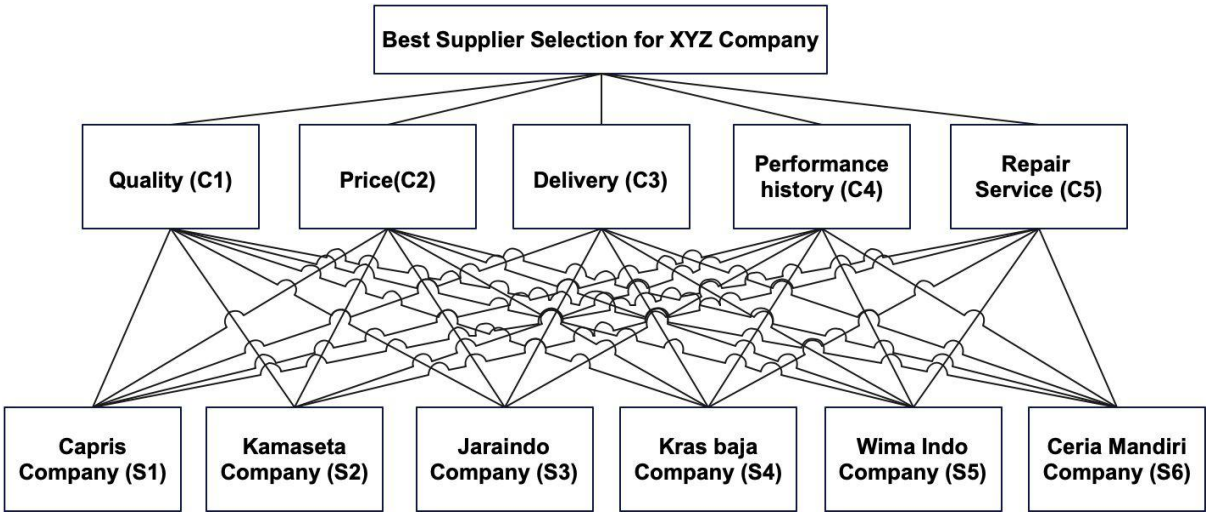

Figure 3. Hierarchical Structure

Based on the results of observations of research activities and interviews conducted at the company, supplier criteria are obtained such as in the aspects of quality, price, delivery, performance history, and repair services. The indicators of supplier selection criteria are in the following table:

Table 2. Supplier Selection Criteria Criteria Indicators

Indicator	Criteria
C1	Quality
C2	Price
C3	Delivery
C4	Performance History
C5	Repair Services

Source: Data processed

In this study, it can be seen that suppliers (suppliers) are alternative suppliers for the selection of the best steel plate raw material suppliers based on criteria indicators. The following is a list of suppliers:

Table 3. Data List of Steel Plate Raw Material Suppliers

No	Supplier Name
1	Company Capris (A)
2	Company Kamaseta (B)
3	Company Jaraindo (C)
4	Company Kras Baja (D)
5	Company Wima Indo (E)
6	Company Cenia Mandiri (F)

Source: Data processed

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The results of the comparison questionnaire in each criterion in the form of numbers 1-9 [18]. This questionnaire was addressed to 5 respondents, namely Senior Manager, Purchasing Manager, Purchasing, Quality Control, and Warehouse. The following is a recapitulation of the results of the interest level questionnaire between criteria:

Table 4. Recapitulation of Questionnaire Results on the Level of Importance Between Criteria

Comparison Criteria	*Senior Manager*	*Purchasing*	*Purchasing*	*Quality*	*Warehouse*	*Geometric Mean*
Quality - Price	5	0,333	3	1	1	1
Quality - *Delivery*	8	5	5	8	3	5
Quality - *Performance history*	3	1	2	0,333	0,333	1
Quality - *Repair Service*	3	3	1	7	0,2	2
Price - *Delivery*	3	5	2	3	5	3
Price - *Performance history*	1	0,333	2	1	3	1
Price – *Repair Service*	2	3	2	4	3	3
Delivery – Performance history	0,333	0,2	0,2	3	1	1
Delivery – Repair Service	1	0,333	0,5	2	1	1
P. history - Repair Service	0,333	3	1	3	2	1

Source: Data processed

The results obtained are then averaged using the geometric mean. This research only requires one answer for the pairwise comparison matrix because the method used is the Analytical Hierarchy Process (AHP) method and the Additive Ratio Assessment (ARAS) method.

Geometric Mean = $\sqrt{(X1)\ (X2)\ \ldots\ (Xn)}$ ..... (9)

X1 : First respondent assessment
X2 : Second respondent assessment
Xn : Respondent assessment n
N : Amount respondents

When the geometric mean value is known, then enter the pairwise comparison matrix stage between criteria. Where the criteria are determined which is continued in the weighting of criteria in supplier selection using the Analytical Hierarchy Process (AHP) method. It is known that the results of the questionnaire the level of importance of the criteria obtained a value of 1 which means that there is a relationship between the criteria is comparable. Criteria relationships that are worth 1, for example, the relationship between quality and performance history, price with performance history, delivery with performance history, delivery with repair service, performance history with quality, performance history with price, performance history with delivery, performance history with repair service, repair service with performance history.

Criteria that are given a value of 1/2 are price with quality, repair services with quality, repair services with price. Conversely, with a value of 2 is quality with price, price with repair services, which means closer to being more important. Furthermore, criteria with a value of 1/3 are price with delivery, price with services, repairs which have a slightly more important meaning. Then the criteria with a value of 1/5 are delivery with quality. Conversely, with a

value of 5, namely quality with delivery which has a more important meaning. The following is a matrix of pairwise comparisons of criteria:

Table 5. Criteria Pairwise Comparison Matrix

	Quality	**Price**	***Delivery***	***Performance history***	***Repair Service***
Quality	1	1	5	1	2
Price	1	1	3	1	3
Delivery	1/5	1/3	1	1	1
P. History	1	1	1	1	1
R. Service	1/2	1/3	1	1	1

Source: Data processed

First level is the goal of selecting the best supplier. The second level is the criteria used in selecting suppliers based on 5 criteria. The third level is the alternative supplier to be selected. Furthermore, the process of making a pairwise comparison matrix is carried out in the form of numbers 1 to 9. It is known that the assessment by the respondent shows the result of 0.135 with the calculation as follows:

1. Sum in the first column: 1 + 1 + 0,2 + 1 + 0,5 = 3,7
2. Sum in the second column: 1 + 1 + 0,333 + 1 + 0,333 = 3,666

The result of summing up each column of the pairwise comparison matrix between criteria is as follows:

Table 6. Summation of Pairwise Comparison Matrix between Criteria

	C1	C2	C3	C4	C5
C1	1	1	5	1	2
C2	1	1	3	1	3
C3	0,2	0,333	1	1	1
C4	1	1	1	1	1
C5	0,5	0,333	1	1	1
Total	**3,7**	**3,666**	**11**	**5**	**8**

Source: Data processed

- C1-C1= 1/3,7 = 0,270
- C2-C1= 1/3,7 = 0,270

Table 7. Normalization of Pairwise Comparison Matrix between Criteria

	C1	**C2**	**C3**	**C4**	**C5**	**Average**
C1	0,270	0,272	0,455	0,200	0,256	0,291
C2	0,270	0,272	0,273	0,200	0,384	0,280
C3	0,054	0.090	0,091	0,200	0,103	0,108
C4	0,270	0,272	0,091	0,200	0,128	0,192
C5	0,135	0,090	0,091	0,200	0,128	0,129
Amount	1	1	1	1	1	1

Source: Data processed

From the table above, it can be seen that each row will be the weight value of the criteria. Feature weight C1 (quality) is 0,270, feature weight C2 (price) is 0,270, feature weight C3 (delivery) is 0,054, feature weight C4 (performance history) is 0,270, and feature weight C5 (repair service) is 0,135.

Table 8. Weight of Each Criterion

Criteria	**Bobot**
Quality C1	0,291
Price C2	0,280
Delivery C3	0,108
Performance History C4	0,192

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Repair Service C5	0,129

Source: Data processed

The consistency ratio value of the consistency index comparison with the pickle number value (RI) [19]. RI value for n = 5 = 1,12 [17].

Table 9: Consistency Ratio

Matrix Size	RI
1	0
2	0
3	0,58
4	0,9
5	1.12
6	1.24
7	1.32
8	1.41
9	1.45
10	1.49

Source: Suryani, 2020

Description:
Kr : Consistency Ratio
CI : Consistency Index
RI : Average Random Consistency
CR : CI/RI
CR : 0,057684/1,12 = 0,0515041

The consistency value of the pairwise comparison matrix between alternatives has a value of CR ≤ 0.1 = 0.0515 ≤ 0.1 and can be said to be consistent or qualified [20].

Table 10. Weighting Matrix Results

Supplier	C1	C2	C3	C4	C5
A0	0,063261	0,05833	0,028421	0,04571424	0,03225
A1	0,037956	0,035	0,011368	0,02742854	0,01935
A2	0,037956	0,023333	0,011368	0,02742857	0,0129
A3	0,004951	0,058333	0,017053	0,02742857	0,0258
A4	0,063261	0,046666	0,017053	0,03657143	0,0258
A5	0,025304	0,035	0,011368	0,01828571	0,0129
A6	0,025304	0,023333	0,011368	0,00914286	0,0129

Source: Data processed

Determination of the optimization function value (Si) and then the calculation of the overall index value for each alternative by summing the weighted normalized decision matrix elements for each alternative using the following formula:
Si= ∑ dij (i = 1, 2, …m:j=1, 2, …, n)
J= 1

The following is the calculation of the value of the optimization function:

Table 11. Weighting Matrix Results

Supplier	**Optimization Function Value**
S0	0,227979
S1	0,131103
S2	0,112987
S3	0,133565
S4	0,189351

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S5	0,102858
S6	0,082049
Total	0,97

Source: Data processed

The utility degree value is calculated by dividing the overall index value of the Ith alternative by the overall index value of the optimal alternative. The following is the ranking formula:

Ki : Si /
So……
……(10)

Description:
Ki : Degree of utility
Si : Optimal function value
So : Sum of optimal function values

The following are the results of the calculation of the degree of utility:

Table 12. Best Supplier Ranking

No	Supplier Name	Ki	Rank
1	Company Kras Baja	0,195207	1
2	Company Jaraindo	0,137696	2
3	Company Capris	0,135158	3
4	Company Kamaseta	0,116481	4
5	Company Wima Indo	0,106039	5
6	Company Cenia Mandiri	0,084586	6

Source: Data processed

In the table above, it can be seen that the supplier who is ranked 1 with a K value of 0.195207 is obtained by company Baja Kras, ranked 2 with a K value of 0.137696 obtained by company Jaraindo, ranked 3 with a K value of 135158 obtained by company Capris, ranked 4 with a K value of 0.116481 obtained by company Kamaseta, ranked 5 with a K value of 0.106039 obtained by company Wima Indo, and ranked 6 with a K value of 0.084586 obtained by company Cenia Mandiri.

CONCLUSION

Based on research activities and data processing carried out using the Analytical Hierarchy Process (AHP) method and the Addidtive Ratio Assessment (ARAS) method, it is known that the order of the best suppliers at company XYZ is company Baja Kras as rank 1 with the acquisition of a K value of 0,195207, rank 2 is company Jaraindo with a K value of 0,137696, rank 3 is company Capris with a K value of 0,135158, rank 4 is company Kamaseta with a K value of 0,116481 and rank 5 is company Wima Indo with a K value of 0,106039 and rank 6 is company Cenia Mandiri with a K value of 0,084586.

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