Vol. 07, No. 02, July 2023, pp. 180-189

INTERNATIONAL JOURNAL OF INNOVATION IN ENTERPRISE SYSTEM

Journal homepage: https://ijies.sie.telkomuniversity.ac.id
e-ISSN: 2580-3050, DOI: https://doi.org/10.25124/ijies.v7i02.240

Implementing AHP Method for Determining Level Priority of Vendor Selection

Kartika Salsabilla Wulandari[1*], Sri Widaningrum[2], Sheila Amalia Salma[3]

[1]School of Industrial and System Engineering
Telkom University, Bandung, Indonesia
kartikasalsabilla11@gmail.com

[2]School of Industrial and System Engineering
Telkom University, Bandung, Indonesia
swidaningrum@telkomuniversity.ac.id

[3]School of Industrial and System Engineering
Telkom University, Bandung, Indonesia
sheilaamalias@telkomuniversity.ac.id

[*]kartikasalsabilla11@gmail.com

ARTICLE INFO

Article history:
Received 15 June 2023
Accepted 26 July 2023
Published 31 July 2023

Keywords:
Vendor; Vendor Selection; Criteria; Analytical Hierarchy Process; Priority Level

ABSTRACT

Vendors are suppliers of goods or services that help the production process of a company. One of the companies that carry out vendor selection is CV Milyarda Cipta Karya which is engaged in fashion. Vendor selection is an activity to determine vendors who will work with the company to help the production process. Based on an assessment of the 30 most popular CV Milyarda Cipta Karya's products on Shopee, there are consumer complaints about the inconsistent quality of materials. This problem is caused by the absence of standards governing the mechanism for selecting fabric vendors. Therefore, it is necessary to know the priority level of vendor selection criteria. Vendor selection criteria are Quality of goods, response time, location, flexibility, price, vendor inventory policy, and vendor service. The data needed in the design are vendor selection criteria according to William J Stevenson, namely hierarchical data and criteria weighting questionnaires. The method used to determine the priority level of vendor selection criteria is the Analytical Hierarchy Process method. Based on the calculation of the AHP method, the results obtained are the criteria for quality of goods 0.19, location 0.12, response time 0.12, vendor inventory policy 0.09, flexibility 0.09, price 0.11, and vendor service 0.28. The largest priority value is vendor service and the smallest is flexibility.

1. INTRODUCTION

Vendors or commonly referred to as suppliers are interested parties, more relevant to the success of manufacturers than other businesses, all companies rely on a level of products and services from other businesses to support their ability to serve their customers [1]. Vendor Selection Vendor selection in general can be defined as an evaluation activity on the supply of goods or services needed by an organization. Vendor selection activity has always been a key element in the purchasing process in an industrial environment, and as one of the main activities in the professional industry [2]. Vendor selection is also a problem with a wide scope and high complexity [3], which is caused by the involvement of many parties in an organization to select a vendor.

Priority Level is the size of the needs arranged in the form of a list according to the level of a person's needs, starting from the most important needs and ending with the needs that can be postponed. In this study, the priority level of vendor selection is used to assist companies in selecting the best vendors so that product quality is consistent.

CV Milyarda Cipta Karya is a UMKM and original hijab brand in Indonesia which has been established since 2015 and is located in Bandung Regency, West Java. CV Milyarda Cipta Karya itself is engaged in a fashion which produces various kinds of hijab. CV Milyarda Cipta Karya collaborates with one main vendor to meet the fabric needs for production. In the hijab production process, CV Milyarda Cipta Karya requires fabric raw materials. To meet the fabric needs, CV Milyarda Cipta Karya collaborates with one main vendor. Vendors are external parties or outside parties who provide or sell goods, both finished goods, semi-finished goods and raw goods that will be resold by the company to consumers. In other words, vendors are suppliers of goods or services that have contractual cooperation ties to the company [4]. The vendor selection mechanism begins with a door-to-door survey, then comparing prices and quality of materials. CV Milyarda Cipta Karya also does not have specific criteria for vendor selection, only material requirements such as thickness, and colors that match the samples provided by the vendor. CV Milyarda Cipta Karya also selects vendors by looking for vendors who have competitive prices.

Problems arise when the main vendor of CV Milyarda Cipta Karya cannot fulfill the demand. To overcome this, the director of CV Milyarda Cipta Karya placed an order with another vendor. However, the quality of the fabric owned by the replacement vendor is different from the main vendor. The quality of materials at replacement vendors such as colors is 5-10% different from the main vendors. For the type of material Cerruti, and Stella there are also differences in thickness, the material does not fall, and the material is less cold, so it does not absorb sweat optimally. This is supported by customer complaints regarding fabric quality. Types of customer complaints obtained from an assessment of thirty hijab products in the e-commerce shopee can be seen in Figure 1.

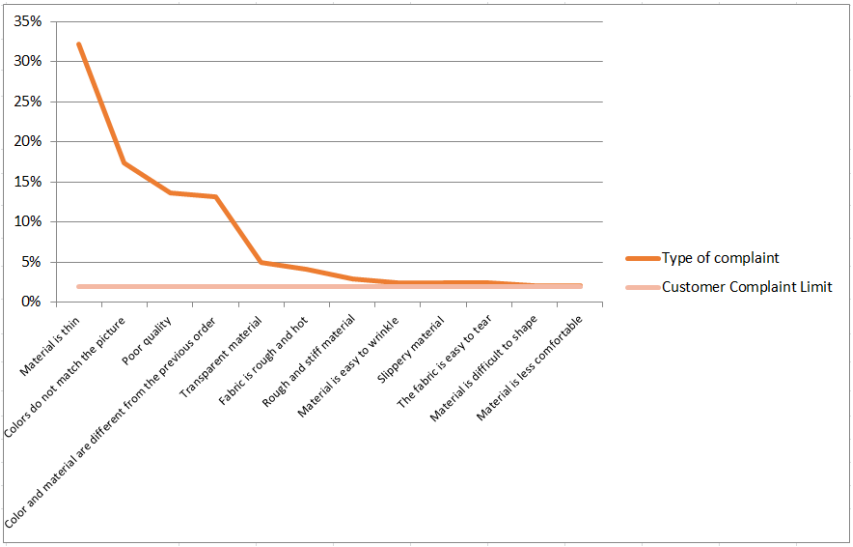

Figure 1 - Total Material Quality Complaints

With a total of 3842 sales obtained from selling the most popular products on E-Commerce Shopee, the percentage for customer complaints is at 6.9%. Where this amount is above the maximum customer complaint limit set by CV Milyarda Cipta Karya, which is 2%. Therefore, it is necessary to make an effort to reduce the number of customer complaints to below 2%.

This decrease in material quality is due to CV Milyarda Cipta Karya not having specific criteria in selecting vendors. According to Sutandi [5], there are 7 criteria for selecting and evaluating vendors or suppliers which can be seen in Table 1 vendor selection criteria below [5].

*kartikasalsabilla11@gmail.com

Table 1 - Criteria for Selecting and Evaluating Vendor

No	Criteria	Information
1	Quality of goods	Good quality materials will be a consideration for companies in choosing vendors.
2	Location	The location of the vendor affects the delivery time and cost. The closer the vendor's location, the time and cost of delivery will be more efficient.
3	Response time	The faster the vendor's response, and the ability to fulfill sudden orders will be better.
4	Vendor inventory policy	When a request comes in, the vendor is ready to ship with existing stock.
5	Flexibility	When incoming demand changes, vendors can quickly adjust.
6	Price	If the vendor has a good price offer such as a discount, it can be a consideration in selecting a vendor.
7.	Service Vendor	service regarding replacement of damaged goods will affect vendor selection.

Vendor selection is an important thing, this is supported by ISO 9001: 2015, especially in clause 8.4.1 which regulates vendor selection. In ISO 9001:2015 clause 8.4.1 states that in vendor selection, the organization shall establish and implement criteria for the evaluation, selection, performance monitoring and re-evaluation of external providers, based on their ability to provide processes or products and services that conform to requirements [6]: Therefore, vendor selection must be considered. The following is the existing condition of vendor selection at CV Milyarda Cipta Karya.

Table 2 - Gap Analysis

Criteria	Current condition	Fulfilled	
		Yes	No
Quality of goods	The quality of the fabric raw materials is inconsistent		V
Location	Vendor locations are quite affordable	V	
Response time	Response time is not fast enough, if you place an order on a whim, the vendor cannot fulfill the request.		V
Vendor inventory policy	The policy is quite good because if there is an incoming order it will be sent immediately if stock is available.	V	
flexibility	Vendor flexibility is lacking, because when an order changes, the vendor cannot fulfill the order.		V
Price	The service is quite good, if the raw materials received are defective or incorrect, they can be returned	V	

Based on the results of the gap analysis in the table above, it can be concluded that the existing conditions at CV Milyarda Cipta Karya still do not fulfill the criteria for selecting vendors according to Sutandi [5].

The AHP Method comprises different decision analytical methods, which are applicable to addressing problems with multiple criteria. According to Saaty [7], Analytical Hierarchy Process (AHP) is a decision method that can solve the decision problem with multi criteria decision. In solving a problem with AHP, there are 5 principals, which are decomposition, comparative judgement, synthesis of priority and logical consistency. The decomposition means that the problem must be derived into hierarchy. Comparative judgement means that the value of the element in same hierarchy must be filled with some degree. The priorities then are synthesized and then checked if the logic is consistency. The step-by-step procedure to use AHP as follows [8]:

1. The decision criteria should be stated in the form of a hierarchy of objectives. The hierarchy has various levels starting with the highest goal and descending through intermediate criteria and sub criteria to finally the lowest level.
2. Evaluate each criterion, sub-criterion, and alternative on a numerical continuum using the factors that are most important for each criterion. For this study, AHP used simple pair wise comparisons to determine ratings and weights so that the analyst can focus on only two issues at a time.
3. After the judgment matrix is developed a priority vector is calculated to prioritize the various elements within the matrix. Priority vectors are calculated by solving an eigenvalue problem and then they are compared by summing them.

4. Assess the consistency of the judgement relative to the consistency ratio IR. To determine an inconsistency measurement, it is first necessary to introduce the consistency index (CI) of the matrix of judgements.

Analytical Hierarchy Process (AHP) is a decision support model developed by Saaty [7]. This decision support model will decompose complex multi-factor or multi-criteria problems into a hierarchy. A hierarchy is a representation of a complex problem in a multi-level structure where the first level is the goal, followed by the level of factors, criteria, sub-criteria, and so on down to the last level of alternatives. With a hierarchy, a complex problem can be decomposed into its groups which are then organized into a hierarchical form so that the problem will appear more structured and systematic [9].

AHP is often used as a problem-solving method compared to other methods for the following reasons [9]:
a. Hierarchical structure, because of the selected criteria, down to the deepest sub-criteria.
b. Considering the validity up to the tolerance limit of the inconsistency of the various criteria and alternatives chosen by the decision maker.
c. Considering the durability of the output of decision-making sensitivity analysis.

AHP is an effective method to solve complex decision making and to help the expert determine the importance degree to make the best decision [10]. Solving a problem with AHP, there are 5 principles, which are decomposition, comparative judgment, synthesis of priority and logical consistency. The decomposition means that the problem must be derived into a hierarchy. Comparative judgment means that the value of the element in the same hierarchy must be filled to some degree. By applying AHP, it is easier to compare and illustrate the qualitative assessments of quantitative values [11].

According to Aulia [12] the AHP method is used to determine the supplier selection system and order allocation. according to Susanti [1] the AHP method is used to determine vendor selection with the smallest risk or optimal profit for the company. according to Wulandari [11] the AHP method is used to select benchmarking partners. Based on previous research related to the use of the AHP method, it can be concluded that the AHP method has often been used to determine criteria.

2. METHOD

Design systematics is a method that describes the flow of design in a structured, systematic, and detailed manner. It describes the planned and systematic steps in the design process to achieve the desired design results and explains how data is collected mechanically. The purpose of making a systematic design is to make it easier for readers to understand the steps in designing priority levels. The following is a conceptual method in designing the priority level of vendor selection criteria at CV Milyarda Cipta Karya.

The method used in this research is the AHP method to determine the priority level of vendor selection. The following are the stages in the AHP method:

1. Determine data hierarchy

In determining vendor selection criteria, discussions were held with the director of CV Milyarda Cipta Karya. Vendor criteria are determined based on vendor selection criteria by William J Stevenson. The hierarchical structure in question can be seen in Figure 2

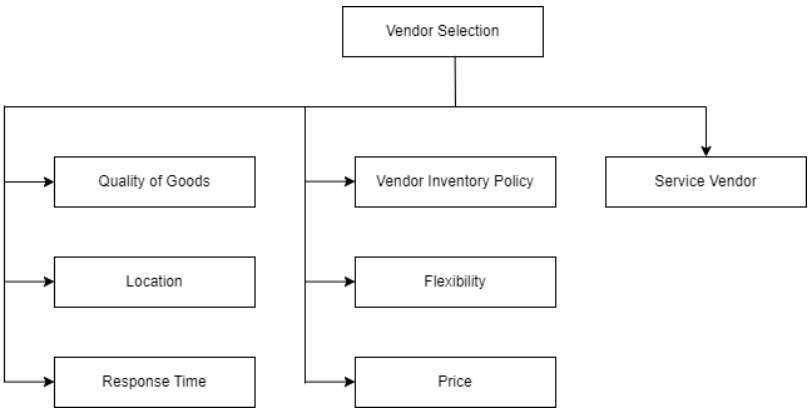

Figure 2 - Hierarchy Vendor Selection Criteria

2. Making a Questionnaire

After determining the hierarchy, the next step is making a questionnaire. The questionnaire contains an assessment of the importance of vendor selection criteria using a scale of 1 to 9 to describe the level of importance of each criterion [13]. An explanation of the scale of importance can be seen in table 3.

Table 3 - Priority Scale

Interest Intensity	Definition
1	As important as anything else
3	A little more important than the others
5	Pretty important compared to the others
7	Very important than others
9	Very important than anything else
2,4,6,8	Score between two adjacent assessments
Reciprocal	If element i has one of the above numbers compared to element j, then j has the opposite value when compared to i

The following are the questions contained in the questionnaire:

Using the pairwise comparison rating scale above, which criterion do you think is more important in vendor selection?

Table 4 – Questionnaire

Criteria	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Criteria
Material Quality																		Location
Material Quality																		Response time
Material Quality																		Vendor inventory policy
Material Quality																		flexibility
Material Quality																		Price
Material Quality																		Vendor Service
Location																		Response time
Location																		Vendor inventory policy
Location																		flexibility
Location																		Price
Location																		Vendor Service

3. Questionnaire Data Collection

Questionnaires were distributed to three respondents. The three respondents are determined by the respondent's criteria, namely authority, responsibility, and work experience [14]. The following are the criteria for research respondents [12]:

a. Respondents have responsibility for the vendor selection process.
b. Respondents have the authority to make decisions in the vendor selection process.
c. Respondents have a minimum work experience of 3 years in the vendor selection process.

Based on the explanation of the criteria above, filling out the vendor selection criteria questionnaire was carried out with three stakeholders who met these criteria. Three stakeholders can be seen in Table 5.

Table 5 - Selected Stakeholders

Position	Length of Service
Director of CV Milyarda Cipta Karya	Director of CV Milyarda Cipta
Production manager	Production manager
Head of Warehouse	Head of Warehouse

4. Data processing

After getting the questionnaire results, calculations are carried out using Microsoft Excel to get the priority vector value. The following are the calculation steps to get the priority vector value.

1. Determining Geomean
   Geomean is done by combining the questionnaire results from the three respondents using the geomean formula in Microsoft Excel.

2. Pairwise Comparison Matrix

$$\text{Matrix x Priority} = \begin{matrix} A1/A1 & A1/A2 & A1/An \\ A2/A1 & A2/A2 & A2/An \\ An/A1 & An/A2 & An/An \end{matrix} \quad (1)$$

   Where An is alternative-n, Pn is Priority vector alternative-n, X n is multiplication of matrix and priority vector of the alternative-n n=1, 2, 3,…, n

3. Determining Normalization
   The calculation is carried out by determining the normalization matrix and then calculating the priority vector value.

$$\frac{total\ matrix\ normalization}{n} \quad (2)$$

   Where n is matrix size

4. Determining Consistency Ratio
   Determination of the random index (RI) according to the random consistency index which can be seen in the Table 6.

Table 6 - Random Consistency Index

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

5. Determining the priority level
   The formula for determining the priority level (CR) is:

$$\text{CR} = \frac{CI}{RI}$$

$$\text{CR} \frac{\lambda \max - n}{n-1} \quad (3)$$

   Where is n is matrix size, and λ max is Eigen Value Maximum

3. RESULT AND DISCUSSION

Analyze the results of questionnaires that have been filled out by selected respondents. Analysis of the questionnaire results is carried out to obtain a priority vector value that will be used to determine the weight of vendor selection criteria with the analytical hierarchy process method.Based on the explanation of the AHP method above, it is hoped that it can help solve the problems found at CV Milyarda Cipta Karya. The following is a calculation with the AHP method in more detail:

1. Determining Geomean

To find out the results of the individual assessment of the respondents and determine the results of income in one group, an assessment is carried out by calculating the geometric mean [15]. The Geomean results are input into the pairwise comparison matrix. The following are the results of the Geomean calculation in Table 7.

Table 7- Geomean Result

Criteria		
Criteria	**GEOMEANS**	**Criteria**
Quality of goods	2.65	Location
Quality of goods	1.00	Response time
Quality of goods	0.72	Vendor inventory policy
Quality of goods	0.26	flexibility
Quality of goods	0.76	Price
Quality of goods	3,17	Service Vendors
Location	1.00	Response time
Location	0.26	Vendor inventory policy
Location	0.15	flexibility
Location	0.15	Price
Location	0.69	Service Vendors
Response time	0.26	Vendor inventory policy
Response time	0.72	flexibility
Response time	0.26	Price
Response time	0.25	Service Vendors
Vendor inventory policy	0.16	flexibility
Vendor inventory policy	0.17	Price
Vendor inventory policy	2.52	Service Vendors
flexibility	0.25	Price
flexibility	1.00	Service Vendors
Price	4.00	Service Vendors

2. Pairwise Comparison Matrix

A pairwise comparison matrix is created for each element in the hierarchy, in this case the vendor selection criteria [7]. Finding the consistency value of each alternative. To get the consistency value of each alternative, a matrix multiplication operation to be performed between the alternative comparison matrix and the priority vector.

The following is a pairwise comparison matrix for each criterion Table 8.

Table 8 - Pairwise Comparison Matrix

Position	Quality of goods	Location	Response time	Vendor inventory policy	flexibility	Price	Service Vendors
Quality of goods	1	2.65	1.00	0.72	0.26	0.76	3,17
Location	2.65	1	1.00	0.26	0.15	0.15	0.69
Response time	1.00	1.00	1	0.26	0.72	0.26	0.25
Vendor inventory policy	0.72	0.26	0.26	1	0.16	0.17	2.52
flexibility	0.26	0.15	0.72	0.16	1	0.25	1.00
Price	0.76	0.15	0.26	0.17	0.25	1	4.00
Service Vendors	3,17	0.69	0.25	2.52	1.00	4.00	1
Total	9.58	5.91	4.50	5,11	3.56	6,60	12.64

Based on the pairwise matrix results in table 8 above, it can be concluded that vendor service is 3.17 more important than the quality of goods, the quality of goods is 2.65 more important than location, location is as important as response time, etc.

3. Normalization

After determining the pairwise comparison matrix, data normalization is then carried out to obtain the priority vector value of each criterion. Normalizing the process by making mean geometric proportions **[16]**. The results of data normalization can be seen in Table 9.

Table 9 - Normalization

Position	Quality of goods	Location	Response time	Vendor inventory policy	flexibility	Price	Service Vendors	Total	*Priority Vector*
Quality of goods	0.10	0.45	0.22	0.14	0.07	0.12	0.25	1.36	0.19
Location	0.28	0.17	0.22	0.05	0.04	0.02	0.05	0.84	0.12
Response time	0.10	0.17	0.22	0.05	0.20	0.04	0.02	0.81	0.12
Vendor inventory policy	0.08	0.04	0.06	0.20	0.05	0.03	0.20	0.65	0.09
flexibility	0.03	0.03	0.16	0.03	0.28	0.04	0.08	Total	*Priority Vector*
Price	0.08	0.03	0.06	0.03	0.07	0.15	0.32	1.36	0.19
Service Vendors	0.33	0.12	0.06	0.49	0.28	0.61	0.08	0.84	0.12
Quality of goods	0.10	0.45	0.22	0.14	0.07	0.12	0.25	0.81	0.12

4. Determining Consistency Ratio

After getting the priority vector results, the next step is to determine the consistency ratio of all criteria. Calculating the consistency ratio by finding the maximum eigenvalue by averaging the values of eigenvalue. From this value, the value of the consistency index and consistency ratio [17]. The consistency ratio value allowed is only (<=0.1). If it exceeds this value, then the process needs to be improved. The results of the consistency value of the criteria can be seen in Table 10.

Table 10 - Determining Consistency Value

Calculating CR Criteria	
λ max	7
CI	0.06
RI	1.32
CR	0.05

Based on the calculation of the consistency value above, it can be seen that the CR value is <0.1. Therefore, the vendor selection criteria questionnaire data is acceptable and can be continued to the next stage.

5. Determining the priority level

After getting the CR <0.1 criteria value, the next step is to sort the vendor selection criteria. The ranking of these criteria is based on the priority vector value that has been obtained previously. The following are the results of determining the priority level of vendor selection criteria can see at Table 11.

Table 11 - Priority Level of Vendor Selection Criteria

RESULTS		
CRITERIA	**PRIORITY VECTOR**	**Rank**
Quality of goods	0.19	2
Location	0.12	3
Response time	0.12	4
Vendor inventory policy	0.09	6
flexibility	0.09	7
Price	0.11	5
Seller service	0.28	1

Based on Table 11, the results show that the first order of vendor selection criteria is vendor service. This must be a question mark why it is not the quality of goods that is number one. This depends on filling out the questionnaire by respondents objectively which has been adjusted to the circumstances of CV Milyarda Cipta Karya.

To help make it easier to determine vendors, there are sub-criteria for each of the criteria that have been set. The sub-criteria below have actually been carried out AHP calculations to determine the priority order, but the resulting CR value is <=0.1 so it cannot be continued to the next stage. Therefore, the sub-criteria only become an added value in the vendor selection criteria.

Table 12 - Sub-Criteria

Criteria	Sub- Criteria
Quality of goods	Material quality
	Stitch quality
	Non-Transparent Material
Location	Within City (< 10 km)
	Out of Town (> 10km)
Response time	Speed of handling orders
	Delivery speed
	Speed of handling defective goods
Vendor inventory policy	Stock availability
	Handling of defective goods
	Rearrange
flexibility	Flexibility order handling
	Delivery flexibility
	Flexibility in dealing with disabilities
Price	Competitive price
	Negotiations
	Vendor service payment methods
Vendor Service	How to order goods
	Shipping method
	How to deal with defective goods

4. CONCLUSION

Based on the problems at CV Milyarda Cipta Karya regarding consumer complaints in the form of inconsistencies in the quality of fabric raw materials because there are no specific criteria for selecting vendors. Then the method that can be used to solve the problem is the Analytical Hierarchy Process. Calculations using the AHP method include geomean calculation, pairwise Comparison Matrix, Normalization, Determining Consistency Ratio and determining the priority level. Therefore, the results will be obtained, namely quality of goods = 0.19; location = 0.12; response time = 0.12; vendor inventory policy = 0.09; flexibility = 0.09; price = 0.11; vendor service = 0.28. Researchers recommend using the AHP method to determine the priority level of vendor selection sub-criteria. So that the priority level of criteria and sub-criteria in the selection of vendors that have been determined can help in determining the best vendor.

REFERENCES

[1] Rinaldo and A. Susanti, "Comparison of Trucking Vendor Selection Analysis Using AHP and Topsis Methods at PT. Yushar Putera Jaya *Teinfo Vol 20,* pp. 12-23, 2019.

[2] Shyur, Hj, Shih and HS, "A hybrid MCDM model for strategic vendor selection mathematical and Computer Modeling 44," pp. 749-761, 200

[3] kar and AK, "A Hybrid Group Decision Support System For Supplier Selection Using Analytical Hierarcy Process, Fuzzy set Theory a Neural Networks," *Journal of Computation ,* pp. 23-33, 2015.

[4] S. Damanik and D. P. Utomo, "Implementasi Metode ROC (Rank Order Centroid) dan Waspas Dalam Sistem Pendukung Keputus Pemilihan Kerjasama Vendor," in *Konferensi Nasional Teknologi Informasi dan Komputer*, Medan, 2020.

[5] K. B. Luhur and Sutandi, "The Effect of Product Quality on Vendor Selection at PT Hitachi Systems Indonesia," *Indonesian Logistics Journa* p. 154, 2020.

[6] ISO. [Online]. Available: https://www.iso.org/home.html.

[7] T. L. Saaty, "Decision Making with The Analytic Hierarchy Process," *Int. J. Services Sicences Vol 1,* pp. 87-88, 2008.

[8] M. Bevilacqua and M. Bragila , "The Analytic Hierarchy Process Applied to Maintenance Strategy Selection," vol. 1, pp. 71-83, 2000.

[9] A. Supriadi, A. Rustandi, D. H. L. Komarlina And G. T. Ardiani, Analytical Hierarchy Process Technique For Determining The Strategy (Savings Of Embroidery Crafts, Sleman: Deepublish, 2018.

[10] H. A. Fatimah and R. Trisminingsih, "Analyzing Success Factors of Enterprise Resource Planning Adoption Using Analytical Hierarcl Process," *International Journal of Innovation in Enterprise System,* vol. 2, p. 45049, December 2018.

[11] S. Wulandari, A. C. Utama and M. Arfidh, "Selecting Benchmarking Partners Using Analytical Hierarchy Process Approach," *Internation Joirnal of Innovation in Enterprise System,* vol. 4, pp. 23-33, July 2020.

[12] R. F. Aulia, "Design of Supplier Selection and Order Allocation System with AHP, SAW, and MOLP Methods," *open library telkc university,* 2022.

[13] Saaty, "The Analytic Hierarchy Process-What It is and how it is used," *Mathl Modelling Vol 9,* 1987.

[14] S. P. Silalahi, "The Influence Of Ethics, Competence, Audit Experience And Situation On Auditor Professional Skepticism," *Econom Journal,* 2013.

[15] T. L. Saaty and L. G. Vargas, "Decision Making With The Analytic Network Process," Springer Science+Business Media, 2006, p. .

[16] M. L. Siregar and Suparno, "Selecting The Best Supplier in Procurement Section (Goods Spot Purchase)," *IPTEK ,* p. 906, 2020.

[17] Yonathan, "Alasan Pemilihan Vendor Terbaik dalam Pengiriman Produk Minimum dalam Kemasan Menggunakan Metode AHP dan Topsis PT CS2 Pola Sheat," *Jurnal Logistik Indonesia,* p. 16, 2020.