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Selection lead logistics provider in consumer goods using AHP – TOPSIS approach

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Abstract
Vendor selection is a strategic activity in order to support the achievement of the company`s success and competitiveness. Significantly, the company has some specific standards in the selection. Therefore, evaluation is needed to see which vendors match the company's criteria. The purpose of this study was to evaluate and select the proposed vendor in a decision support system using the AHP and TOPSIS approaches. The AHP method is used to determine the importance of the criteria, while the TOPSIS method is used to rank alternatives. The results show that Provider 1 has the highest score compared to other alternatives with a value of 0.852. Sensitivity analysis shows that the proposed AHP and TOPSIS methods are robust, suitable for this problem, and have a low rate of change

Keywords:
AHP;
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INTRODUCTION

The vendor selection process is one of the company's important activities managed by the procurement department. Vendor selection has a significant effect on strategic and operational performance in an organization [1]. Choosing the right vendor can increase quality and flexibility to meet customer satisfaction [2]. The main objective of selecting a vendor is to reduce investment risk, maximize service level and develop intimate and long-term relationships between service providers and principals [3].

Therefore, purchasing managers must develop and use effective processes to find qualified vendors to provide business qualifications [4]. Therefore, it is necessary to evaluate the selection to determine the right vendor that fits the company's criteria. Distribution involves third parties as a bridge to complete a good process supply chain [5]. The distribution process is determined by the efficiency of each logistics service provider used [6]. In recent years, logistics services in Indonesia are quite promising. One of the reasons is the increasing purchasing power of consumers. This is followed by increasing competition in the logistics sector to provide a competitive advantage for service providers [6].

Based on the Logistic Performance Index, the selected criteria completed measurement in year on year for based indicator each country: customer, infrastructure, international shipping, logistics competency, tracking & tracing, and on time. Indonesia's ranking increased from the previous year in position is 63 in 2016 to position is 46 in 2018 out of 160 countries based on world bank data. Logistics sector in Indonesia need to be improve for customer criteria. Vendors are an important part of the supply chain and will affect the company's performance Figure 1.

Therefore, companies need to assess vendors or suppliers carefully and appropriately. The selection of vendors is a strategic activity, especially if the vendor will supply important goods and will be used in the long term. So, for the smooth production process, it is necessary to know in advance the most important criteria to be used as a benchmark in vendor selection [7].

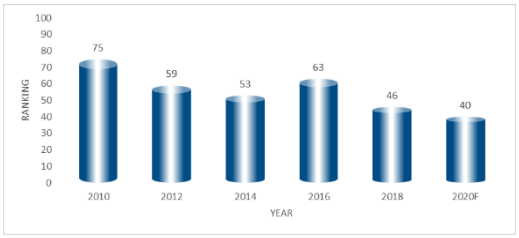

Figure 1. Logistics Performance Index [8]

Fast-moving consumer goods industry in Indonesia will can using priority criteria are safety, quality, delivery, morale and cost meet with type of industry [9]. Today's highly competitive business environment requires good business partners to utilize the right vendors in managing very long supply chain processes from raw materials to delivering products to consumers [2]. Vendor selection is a very strategic activity because various vendors have different advantages and disadvantages according to company needs [11].

The effectiveness of vendor selection is considered critical to the success of the organization. Researchers agree on the importance of vendors and providing resources in managing services in organizations. Product distribution costs are considered as dominant costs in some companies [10].

This illustrates the importance of strong collaboration between organizations and vendors, in one organization have much 3PL will generate complexity item of activity, contract, and control [11]. Selection lead logistics provider will convert to reduce complexity and simplification from more 3PL in organization to become one 3PL. They are associated with lower costs, quality and innovation in business, helping organizations achieve a sustainable competitive advantage [12]. Henceforth, organizations must find ways to select the best among them to be their partners in the supply chain [11].

Third Party Logistics (3PL) is a third-party company that provides outsourcing logistics services, both to companies and individuals. The services provided may be for one or more functions in supply chain management, particularly in terms of warehousing and distribution. Thus, this 3PL logistics company will become a partner in managing all end-to-end transportation and warehouse needs [13].

The relationship between 3PL companies and their customers has changed and evolved over time. What started as a mere contract has developed into partnerships and agreements, bringing mutual benefits and lasting relationships. Strategic alliances between 3PL service providers and their customers are important to ensure service quality [14].

The steps involved in establishing and building a relationship with the 3PL. For illustration purposes, assume the model must be used from the perspective of a manufacturing company, because it can identify the possibility of establishing connections with third-party logistics providers [15]. Adopted both method in this research between AHP, and TOPSIS based on selected journal reference to apply in Indonesia consumer goods. Output from AHP is the most selected criteria, and TOPSIS will continue to ranking mechanism vendor result [16].

Selection lead logistics provider in this study begins with determining the criteria obtained from literature studies adjusted and selected by the company's decision-maker [6]. The criteria specified are: Quality, Price/Cost, Services, Flexibility, Location, and On Time Delivery. After these criteria are determined, the decision-maker assigns weight for each criterion with AHP pairwise comparison. These criteria will be used and calculated with the fuzzy-TOPSIS method, and the result will be used as weights for the TOPSIS method [17]. Finally, the decision-maker determines the weights of each vendor using the AHP – TOPSIS method. The results obtained can be used as a reference for the company in determining the vendor selection.

METHODS

Analytical Hierarchy Process (AHP)

In this study, the proposed for the selection of Lead Logistics Provider (LLP). Alternative vendors are provided in accordance with the ongoing processes in the company, and the criteria used are obtained from the perspective of the company's decision makers. 3PL criteria and alternatives are shown in Figure 2.

The steps of decision making using the AHP method [18] are as follows:

1. Defining the problem and goals to be achieved by creating a Hierarchy
2. Making pairwise comparison matrix data per level per respondent
3. Calculating the priority of each criterion
4. Calculating the vector value

$$CI = \frac{\lambda_{maximum} - n}{n - 1} \quad (1)$$

n = total criteria or sub criteria
CI = consistency index
To find the *CR*, $\boldsymbol{CR = CI/RI}$
CR = consistency ratio
CI = consistency index
RI = index value random / Random, as listed in Table 1.

Table 1. Index value random

OM	1	2	3	4	5	6
RI	0	0	0.58	0.9	1.12	1.24

5. Calculating Eigenvalues, the number of matrices /N (the number of matrices = vector) then n is the number of criteria.
6. Calculating the consistency index value
7. Final alternative ranking from AHP

Complex decision problems are arranged in a hierarchy in the first stage. The original AHP breaks down multi-criteria decisions into simple steps. problems in a hierarchy of interrelated decision criteria, decision alternatives [19]. At each level, the criteria are compared in pairs according selected journal [20] to their level of influence and based on criteria determined at higher levels. In AHP, multiple pairwise comparisons are based on a comparison scale. Basically, the multi-criteria mathematical formulation with the AHP model is carried out using a matrix. In an operating subsystem there are n operating elements, namely operating elements A1, A2, …, An, then the result of the comparison is that the pair of operating elements will form a comparison matrix [21]. Pairwise comparisons start from the highest hierarchical level, where a criterion is used as the basis for making pairwise comparisons such as Table 2.

The AHP method requires an assessment using expert respondents, therefore this study selects respondents who are considered experts in the field of evaluating suppliers. What is meant by expert respondents here are people who are experienced have past year of service in company more than five years in the field of evaluating vendor performance in the procurement of supply chain logistics [2].

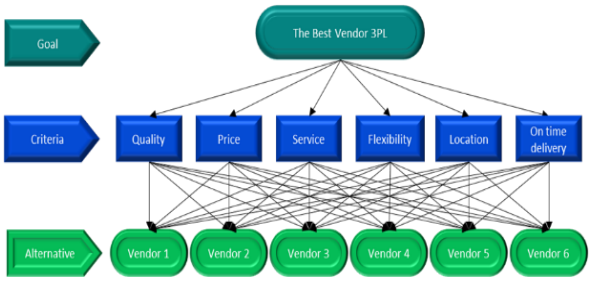

Figure 2. AHP Process

Table 2. Pair Comparison

	A_1	A_2	…	A_n
A_1	a_{11}	a_{12}	…	a_{1n}
A_2	a_{21}	a_{22}	…	a_{2n}
…	…	…	…	…
A_n	a_{n2}	a_{n2}		a_{nn}

The evaluation step begins with the Analytical Hierarchy Process (AHP) approach, each criterion is weighted, and consistency is calculated. If the results are appropriate, then proceed to the next stage, namely AHP. The AHP step is used to convert the linguistic criteria into several steps and then the criteria weights are obtained [22].

Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)

Basically, the decision-making method that can be used is called Multi Criteria Decision (MDCM). MDCM is a decision-making method that is the best alternative from a number of choices based on certain criteria. The criteria in question can be in the form of measures, rules, or standards used in the decision-making process [13]. The usefulness of the TOPSIS method is that TOPSIS has been widely used in financial investment decision-making applications, company performance comparisons, internal comparisons, a specific industry, operating system selection, customer evaluation, and robot design.

The decision-making stages using the TOPSIS method are:

1. Design a decision-making matrix. According to the decision matrix X, n criteria will be used to evaluate m alternatives.

$$D = \begin{array}{c} \\ A_1 \\ A_2 \\ \cdot \\ \cdot \\ A_i \\ \cdot \\ \cdot \\ A_m \end{array} \begin{pmatrix} X_1 & X_2 & \ldots & X_j & \ldots & X_n \\ X_{11} & X_{12} & \ldots & X_{1j} & \ldots & X_{1n} \\ X_{21} & X_{22} & \ldots & X_{2j} & \ldots & X_{2n} \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ X_{i1} & X_{i2} & \ldots & X_{ij} & \ldots & X_{in} \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ X_{m1} & X_{m2} & \ldots & X_{mj} & \ldots & X_{mn} \end{pmatrix} \quad (2)$$

a_1= (i = 1, 2, 3, ..., m) are the possible alternatives, x_j= (j = 1, 2, 3, ..., n) are the attribute which the alternatives performance is measured, ij= alternatives performance ai with attribute reference x_j.

2. Constructing a Normalized Decision Matrix. The element rij is the result of the decision matrix R using the Euclidean length of a vector method as follows:

$$r_{ij} \frac{X_{ij}}{\sqrt{\sum Xi^{j2}}} \quad (3)$$

3. Create a weighted normalized decision matrix as follows:

$$V_{ij} = W_i r_{ij} \quad (4)$$

4. Determine the positive ideal solution and the negative ideal solution. The positive ideal solution is denoted A+, as follows:

$$A^+ = \{(\max V_{ij} \mid j \varepsilon J), (\min V_{ij} \mid j \varepsilon J')\} \quad (5)$$

While the negative ideal solution is denoted A^- as in equation below:

$$A^- = \{(\min V_{ij} \mid j \varepsilon J), (\max V_{ij} \mid j \varepsilon J')\} \quad (6)$$

5. Calculating Alternatives. The calculation of separation is a measurement of the distance from an alternative to a positive ideal solution and a negative ideal solution, as in (7) and (8)

$$S_i^+ = \sqrt{\sum} (V_{ij} - V_j^+)^2 \quad (7)$$

$$S_i^- = \sqrt{\sum} (V_{ij} - V_j^-)^2 \quad (8)$$

6. Calculate the relative closeness to the ideal solution using the following (9):

$$Ci^+ = Si^- / (Si^+ + Si^-), 0 \leq Ci^+ \leq 1 \quad (9)$$

7. Ranking alternatives, sorted from the largest C+ value to the smallest value. The alternative with the largest C+ value is the best solution.

However, there are still shortcomings of a method, including the TOPSIS method. The drawback is that it requires a weight to be calculated using AHP to continue calculating the next data using TOPSIS.

RESULTS AND DISCUSSION

Existing in PZ has 3 providers logistics service, namely KML, DHL, and GAC also in house transporter manage ourself. 3PL operated since 2014 and they will elaborate each activity to become one 3PL with call lead logistics provider could managing all activity. This section describes the results of vendor selection using AHP and fuzzy TOPSIS based on a decision support system. As explained in the previous section, vendor selection needs to be carried out in several stages.

Stage1: AHP begins by determining the importance of each criterion using the AHP pairwise comparison matrix, which is determined by company experts from the purchasing department. The results of pairwise comparisons with the AHP scale, followed by dividing each column element by the number of all column elements, the AHP pairwise comparison matrix was normalized using Table 3.

Stage 2: Making pairwise comparison matrix data per level per respondent Table 4.

Stage 3: calculate the priority of each criterion, by dividing the contents of the pairwise comparison matrix by the number of corresponding columns, then adding up each row. After that, the sum result is divided by the number of criteria so that the priority weight in Table 5.

Table 3. Instrument

Criteria	Alternative
Quality	DHL Supply Chain Indonesia
Price/cost	Kamadjaja Logistics
Service	GAC Samudra Logistics
Flexibility	Puninar Logistics
Location	Linfox Logistics
On time delivery	LF Logistics

Table 4. Pairwise comparison matrix per respondent

Alternative/ Criteria	Quality	Price	Service	Flexibility	Location	Ontime delivery
DHL	5	3	4	4	4	5
KML	4	4	3	3	5	4
GSL	5	4	4	4	4	4
PNL	3	4	4	3	4	4
LNL	5	4	5	4	3	4
LFL	4	4	4	4	4	5

Alternative/ Criteria	Quality	Price	Service	Flexibility	Location	Ontime delivery
DHL	4	4	5	4	4	4
KML	4	4	4	4	5	4
GSL	5	4	4	5	4	5
PNL	3	5	4	5	4	3
LNL	3	4	5	5	3	4
LFL	3	5	4	4	4	4

Alternative/ Criteria	Quality	Price	Service	Flexibility	Location	Ontime delivery
DHL	5	3	4	5	4	5
KML	3	4	5	4	4	4
GSL	4	4	3	4	4	5
PNL	3	4	4	4	4	4
LNL	4	4	5	4	4	3
LFL	4	4	4	4	4	4

Table 5. Paired Matrix

Paire Matric	Quality	Price	Service	Flexibility	Location	Ontime delivery	Weight	Priority
DHL	0.48	0.75	0.38	0.35	0.13	0.37	0.41	0.471
KML	0.08	0.12	0.26	0.21	0.18	0.26	0.18	0.151
GSL	0.08	0.03	0.06	0.02	0.13	0.26	0.09	0.090
PNL	0.10	0.04	0.26	0.07	0.26	0.02	0.12	0.096
LNL	0.16	0.03	0.02	0.01	0.04	0.01	0.05	0.077
LFL	0.11	0.04	0.02	0.35	0.26	0.09	0.14	0.122

Table 6. Vector calculation result

	K1	K2	K3	K4	K5	K6	Vector
Vector	0.864	1.214	1.045	1.295	0.588	1.185	6.191

Stage 4: Then calculate the vector value, as listed in Table 6.
Stage 5: Calculating Eigenvalues, the number of matrices /N (the number of matrices = vector) then n is the number of criteria. So, the following results are obtained:
Eigen Value = 1.031872017**.**
Stage 6: Calculating the consistency index value
CI = - 0.993625597
Stage 7: The next stage is to perform calculations to find a ranking based on the weight of each criterion, by multiplying the alternative priorities of each criterion with the priority weight of the criteria and then adding them up show in Table 7.

Fuzzy-TOPSIS is used to make an assessment of the intangible criteria of provider selection so that this can be considered as a parameter to measure the fulfillment of the requirements of each provider [23]. Based on intangible criteria, the selection of the right vendor can be shown by the best ranking with closeness coefficient.

Table 7. Ranking results based on AHP results

Provider	Weight	Ranking
DHL	0.41	1
KML	0.18	2
GSL	0.09	5
PNL	0.12	4
LNL	0.05	6
LFL	0.14	3

The following are the steps in processing data using the fuzzy-TOPSIS method.
1. Form a decision matrix.

$$D = \begin{pmatrix} 0.48 & 0.75 & 0.38 & 0.35 & 0.13 & 0.37 \\ 0.08 & 0.12 & 0.26 & 0.21 & 0.18 & 0.26 \\ 0.08 & 0.03 & 0.06 & 0.02 & 0.13 & 0.26 \\ 0.10 & 0.04 & 0.26 & 0.07 & 0.26 & 0.02 \\ 0.16 & 0.03 & 0.02 & 0.01 & 0.04 & 0.01 \\ 0.12 & 0.04 & 0.02 & 0.35 & 0.26 & 0.09 \end{pmatrix}$$

2. Normalize the decision matrix D by using (3)

r_{ij} = element of the normalized decision matrix R,
x_{ij} = element of the decision matrix X.
Where Weight is obtained from W = {5 5 4 4 5 4}

$$R = \begin{pmatrix} 0.48 & 0.75 & 0.38 & 0.35 & 0.13 & 0.37 \\ 0.08 & 0.12 & 0.26 & 0.21 & 0.18 & 0.26 \\ 0.08 & 0.03 & 0.06 & 0.02 & 0.13 & 0.26 \\ 0.10 & 0.04 & 0.26 & 0.07 & 0.26 & 0.02 \\ 0.16 & 0.03 & 0.02 & 0.01 & 0.04 & 0.01 \\ 0.12 & 0.04 & 0.02 & 0.35 & 0.26 & 0.09 \end{pmatrix}$$

3. After the normalization of the matrix is made, then the weighting is carried out so that the normalized matrix results will be obtained as below.
The matrix below is obtained from
Weighted normalized matrix =
Matrix D/Matrix W

$$Y = \begin{pmatrix} 0.8865 & 0.9832 & 0.7131 & 0.6449 & 0.2885 & 0.6984 \\ 0.1477 & 0.1573 & 0.4879 & 0.3870 & 0.3995 & 0.4907 \\ 0.1477 & 0.0393 & 0.1126 & 0.0369 & 0.2885 & 0.4907 \\ 0.1847 & 0.0524 & 0.4879 & 0.1290 & 0.5771 & 0.0377 \\ 0.2955 & 0.0393 & 0.0375 & 0.0184 & 0.0888 & 0.0189 \\ 0.2216 & 0.0524 & 0.0375 & 0.6449 & 0.5771 & 0.1699 \end{pmatrix}$$

= 0.48 / 0.54 = 0.8865

4. Determine the positive ideal solution and the negative ideal solution, as in (7) and (8).
$A+ = \{(\max v_{ij} \mid j \epsilon J), (\min v_{ij} \mid j \epsilon J')\}$
$A- = \{(\min v_{ij} \mid j \epsilon J), (\max v_{ij} \mid j \epsilon J')\}$
Look for the value of A+ = Max from column 1 to column 6
Look for the value of A-= Min from column 1 to column 6
Then we get the following results
5. Calculate the size of the separation. The separation of each positive ideal alternative is given by Table 8.

Table 8. Separation of each positive ideal

	A1	A2	A3	A4	A5	A6
A^+	0.8865	0.9832	0.7131	0.6449	0.5771	0.6984
A^-	0.1477	0.0393	0.0375	0.0184	0.0888	0.0189

6. Calculate the relative proximity to the ideal solution. The relative proximity of A_i to A+ is defined as the ranking of the preferred order, as listed in Table 9.

Table 9. Ranking based on the calculation of AHP-TOPSIS

	Provider	Proximity Value	Alternative
DHL		0.8526	1
KML		0.4075	2
GSL		0.2549	3
PNL		0.3171	4
LNL		0.0813	5
LFL		0.3622	6

Sensitivity Analysis

What Analysis is a sensitivity analysis by remodeling the resulting system whose purpose is to answer the question "what happens to the output if there is a change in the input". If the changes in the input data are not too significant, it can also be called a sensitivity analysis, namely how sensitive the output data is to small changes that occur in the main parameters to the output data [24].

The weight of the main criteria has a significant effect on the final priority of the alternative. Slight changes in relative weights can lead to significant changes in the final ranking. Since these criterion weights are generally based on highly subjective judgments, it is necessary to test the stability of the ratings under different criterion weights [2]. Sensitivity analysis is carried out to maintain the precautionary principle in applying changes to risk parameters. For this purpose, a sensitivity analysis is performed using scenarios that represent alternative future developments or multiple perspectives on the relative weight of the criteria. By decreasing or increasing the weight of each criterion, changes in the ranking of alternatives can be observed. As a result, the sensitivity analysis provides information about rating stability. If the ratings obtained are highly susceptible to small changes in the weight criteria, it is advisable to evaluate the weights with caution [25].

In order a sensitivity analysis, in this study by adding and subtracting each criterion's weight by 25% on one of the criteria with the others still, then it is done to reduce the sensitivity of -25% to weight, as shown in Figure 3.

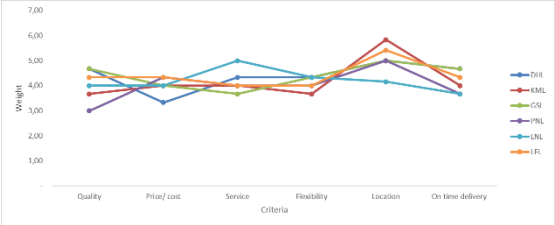

Figure 3. Sensitivity analysis +25% weight

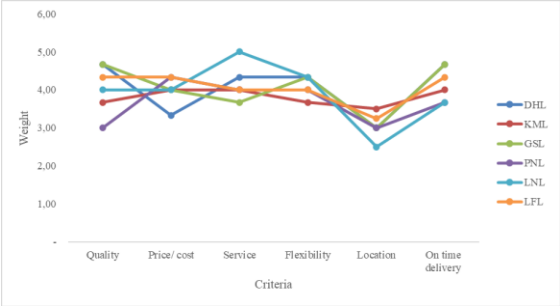

Figure 4. Sensitivity analysis -25% location

From the process of adding this sensitivity analysis method, it was found that there was a change in ranking in terms of features at the addition of +25%, as presented in Figure 4.The criteria that were very sensitive to DHL providers were sensitive to changes in price, service and location criteria, KML was sensitive to changes in location criteria, GSL was sensitive to changes price, service and location criteria, PNL is stable with changes in the six existing criteria, LNL is sensitive to changes in location criteria, LFL is sensitive to changes in price criteria and location. This proves that the logistics service sector is very sensitive to location, price and service criteria. And followed by the criteria of quality, flexibility and timely delivery.

The final results of the rating after adding and subtracting using "what if analysis" did not change in total, it can be concluded that the weighting in this study is correct and the resulting framework can be used in the process of selecting third party logistics providers. However, by conducting a sensitivity analysis we can find out or we can mitigate if in the future there are changes in terms of location and price criteria in the vendor selection process with this existing framework.

CONCLUSION

After carrying out all stages of research using the AHP and TOPSIS methods, the selected lead logistics provider using the AHP-TOPSIS method can be used by companies in a more appropriate decision-making process. in the selection of 3PL vendors so as to speed up the selection process and avoid losses due to vendor selection errors. Also perform sensitivity analysis with what if analysis is carried out to see changes

in output if there is a change in input. This is necessary to see the robustness of the resulting framework. In this study, an experiment was conducted by adding input (+25%) and subtracting (-25%). On all the criteria to see, is there a change in ranking. From the sensitivity analysis process, it was found that the very sensitive location and price changed but did not change the selected alternative vendor. This proves that the resulting framework is reliable.

This research has done comparison between AHP, and TOPSIS a very good process for selected vendor alternatives with the research process using AHP - TOPSIS as the method used, that the criteria used have been tested for validity and reliability and the results of AHP - TOPSIS added sensitivity analysis so that mitigation can be done if there are changes alternative vendors. Suggestions for further research may try a MCDM with new method such as SSM, ISM, and SAW with several criteria can be used to weight the criteria like AHP – TOPSIS.

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