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Analysis of Vendor Selection Decision Support System Using Analytical Hierarchy Process Method in Procurement of Spare Part Goods at PT Djakarta Lloyd (PERSERO)

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***Abstract* - This paper discusses the analytic hierarchy process method for decision-making from multi-criteria and is used to solve complex problems in vendor selection. The identified criteria were used in conjunction with the theoretical concepts from AHP only and the "Expert Choice" computerized software program based on AHP in carrying out the development of the vendor selection model. This study aims to use this approach to be able to build a vendor selection system using the priority weight values of the criteria for quality, price, warranty, and delivery time. The researcher used a questionnaire to several users from the fleet and operations division. From this research, it is known that the warranty is the highest weighting criterion among the existing criteria with a value of 0.300 of all criteria, followed by the criteria for quality of goods with a value of 0.265 and the criteria for delivery time with a value of 0.242, and the price criteria with a value of 0.194. From this research, it is also known that PT KMI was chosen as the top supplier because it has the highest value weight.**

Keywords: Vendor, Selection, Criteria, Alternative, Analytic Hierarchy Process.

I. INTRODUCTION

The selection of a vendor who is competent and able to provide needs according to the required specifications is the first step to maintaining product quality. To be able to meet the needs of a company consistently, sustainably and with quality, vendor selection must be carried out to obtain appropriate results for the proposing division within the company. Shipping companies have extensive relationships with many relationships, one of which is with vendors. Vendors are companies that provide material needs that cannot be provided by the company itself. Companies often do not get competent vendors because, in terms of determining vendors, they are still based on intuition and good relations but are not accompanied by measuring tools such as determining rational and measurable criteria and evaluation methods.

PT Djakarta Lloyd, which was founded on August 18, 1950, is a pioneer shipping company in the transportation of goods in the territory of Indonesia. In maintaining the quality of goods transportation services by the sailing time target, spare parts are needed to support operational activities to support the performance of the Djakarta Lloyd transport fleet. All procurement related to spare parts is directly carried out by the logistics division. In a business process, logistics activities have a very important role to support the performance of the Djakarta Lloyd fleet in distributing goods from the owner of the goods to the recipient of the goods. Therefore, currently, many companies choose to be able to continue to develop their business in the field of logistics services. However, all logistics service vendor companies have their respective advantages and disadvantages(Juli Astuti, 2017).

Procurement to support one of the supply chain activities is an activity to be able to provide the operational needs of the Djakarta Lloyd fleet which is expected to support the operational performance of the owned fleet. The specifications of the goods, the quantities required, and the prices and sources can be accounted for. Selection in the procurement process itself has two types, namely conventionally or manually through SAP and electronically or often called e-procurement.

In an activity in the supply chain sector, the company must be able to optimize the best possible use of time, determine the location, and maintain the number of goods. In general, each criterion considered in the vendor selection process is in terms of administration, quality, delivery time, vendor's financial condition, technical, and price. Vendor selection is a very important activity for the company, especially if the vendor will provide goods that have a high level of urgency or will be used for a long time as an important vendor.

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The company several times did not get vendors that matched their needs because the criteria in determining these vendors were only based on intuition and relationships but were not accompanied by rational and measurable criteria and evaluation methods.

II. LITERATURE REVIEW

2.1 Supply Chain

A supply chain is a network of companies that work together to create and distribute a product/service to end-users (customers). Supply chain activity itself starts from a series of suppliers, then factories, distributors, shops, or retailers, as well as companies that support company activities such as shipping service companies (logistics). In the supply chain, 3 types of flow must be used starting from upstream (upstream, the side where an item is still in the form of raw materials) to downstream (downstream, the side where an item has become a final product or final product that is ready to be distributed and consumed) by the customer, is the flow of material, information, and money.

The supply chain itself consists of all parties involved either directly or indirectly in the process to be able to meet customer demands. The supply chain does not only include producers and suppliers but more than that there is a role from transporters, warehouses, retailers, or retailers, even from the customers themselves. In any organization, such as a manufacturer, the supply chain includes all the functions involved in the process of receiving and fulfilling customer demands. These functions include, but are not limited to the development of new products/services for innovation, marketing, operations, distribution patterns, finance, and customer service(Chopra, S. and Meindl, 2007).

2.2 Criteria, Attributes, & Objective

In this case, the words criteria and attributes are often used synonymously in the literature on multi-criteria decision making (MCDM), which is sometimes referred to as multi-attribute decision analysis (MADA).

Criterion is a general term and includes the concept of attributes as well as objectives. Attributes in this case are measurable quantities whose values can reflect the extent to which certain goals can be achieved. The goal in this case is a statement about the expected state of the system under consideration (Chankong and Y. Y. Haimes, 1983). This indicates the direction of improvement of one or more attributes. Objectives are seen as functionally derived from one attribute(Malczewski, 1999).

Some things allow for a formal relationship between goals and attributes, but usually, the relationship is informal. To be able to assign an attribute to a particular goal, two properties, namely completeness, and measurability, must be met. An attribute can be said to be comprehensive if it gets a sufficient value to indicate the extent to which the goal can be achieved and can be measured if it is practical enough to be able to provide a value in the relevant measurement scale.

2.3 Analytical Hierarchy Process

The analytic hierarchy process (AHP) method is a basic approach to determining decision-making for vendor selection activities with a hierarchical system. AHP itself is designed to be able to overcome rationale and intuition in determining to choose the best from several available alternatives by going through stages that have been evaluated and paying attention to certain criteria. In this process the decision-maker makes an assessment using pair wise comparisons which can then be used to compile an overall ranking of the prioritized alternatives. AHP allows for inconsistencies in assessment and can provide opportunities to improve consistency.

Analytical hierarchy process (AHP) can be interpreted as one of the most important methods in determining the decision to choose a vendor because it can provide a practical framework for solving many problems. This is one of the multi-criteria decision making (MCDM) approaches that allow being ability to make decisions and solve complex problems through analysis and can simplify problems, in addition to flexibility and ability to be used in various situations and different industries (Golmohammadi, M., Cubero, J., Peñalver, J., Quesada, J. M., López, M. M., & Llop, 2007).

The simplest form is to structure a decision-making problem by dividing the problem into three levels. The highest level (top-level) is the level to make decisions followed by several criteria at the second level and other alternatives at the third level (Hillier et al., n.d.). With this hierarchy, a problem that is quite complex can be broken down into several groups which can then be arranged into a hierarchical form so that all problems will appear more structured and systematic.

AHP itself is a method that is often used to solve complex and unstructured problems into several groups, by arranging the groups into a hierarchy, then entering numeric values as a substitute for human perception in doing relative comparisons.

With a synthesis, it will be able to determine which element has the highest priority.

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2.4 Basic Principles of Analytical Hierarchy Process

A complex system can be understood by breaking it down into several supporting elements, arranging these elements hierarchically, and combining them or synthesizing them. The problem hierarchy is structured to be able to assist the decision-making process by considering all the elements that exist to determine the decisions involved in the system. Most problems seem more difficult to solve because the solution process is carried out without seeing the problem as a system with a certain structure.

At the highest level of the hierarchy, stated goals, and objectives of the system to be able to find a solution to the problem. The next level is the elaboration of some of these goals. The hierarchy in the AHP method is a description of the elements that have been arranged in several levels, with each level consisting of several homogeneous elements(Firdaus, Madelan and Saluy, 2021). An element becomes a criterion and benchmark for the elements below it. In building a hierarchy, there are no specific guidelines to follow. Hierarchies can depend on the compiler's ability to understand a problem. However, it should be based on the type of decision to be taken.

To ensure that all of the criteria created in the vendor selection process match the objectives of the problem, they must have the following characteristics:

Table 1: Characteristics of analytical hierarchy process

No.	Description	Explain
1	**Minimum**	The number of criteria is attempted as optimally as possible to facilitate analysis
2	**Independent**	Criteria do not overlap and there should be no repetition of criteria for the same purpose
3	**Done**	All criteria must cover all important aspects of a problem
4	**Operation**	All criteria must be measurable and analyzed by quantitative and qualitative methods and can be communicated

Furthermore, all criteria and alternatives must be carried out using a pairwise comparison process. Various problems can be described on a scale of 1 to 9, which is the best scale for expressing opinions. The value and definition of each qualitative opinion of the comparison scale can be measured using an analytical table as shown in the table.

Table 2: Pairwise comparison of pair rating scale

Intensity Important	Information
1	Both elements are equally important
3	One element is slightly more important than the other
5	Elements one is more important than the other elements
7	Elements that one is more absolutely important than the other elements
9	Elements that one is important compared to other elements
2,4,6,8	the value between two adjacent consideration values
Opposite	If activity I gets one point compared to activity J, then K has the opposite value compared to I.

2.5 Vendor Relationship Management

Vendor relationship management is defined as how a company interacts with its suppliers, this can be said to be the key to the supply chain management process (T. C. Carter, 2003). Vendor relationship management is an inclusive approach to able to manage any existing problems and interacting with organizations or companies that can provide goods and services for a company. This includes the communications, business practices, negotiations, methodologies, and software used to develop and manage relationships with Vendors, the benefits of which can be lower costs, higher quality, and better forecasts. within the framework of a mutually beneficial relationship

2.6 Method

The data analysis that will be used in this research is by using the Analytical hierarchy process (AHP) method. Calculations were performed using the help of expert choice 11 software. Expert choice is a type of software that can be widely used in analyzing the results of AHP weighting. Expert choice is software that can help determine decision-makers and can examine and solve problems involving several criteria at the evaluation stage. In its use, this software uses the Analytical hierarchy process (AHP) methodology to model decision problems and evaluate desired alternatives. The functional hierarchy has broad general goals (goals) at the highest level (better known as the zero level). The lower level corresponds to the respective criteria and sub-criteria to choose among alternatives. Respondents to be studied are employees in the fleet and operations division with a total of 8 employees. The data collection technique is through surveys.

Table 3: Steps of analytical hierarchy process

Step	Description
1	Develop a hierarchical structure of the problem
2	Creating a comparison matrix
3	Calculating the weight / priority of each variable at the level (criteria) steps

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4	Calculating the consistency index
5	Calculating consistency ratio
6	Calculating the weight/priority of each variable
7	From the steps above, it can be solved easily if the data is processed using expert choice software

After a problem is found and has been parsed and defined, the next step is to determine the process of solving a problem that can be fully implemented into its elements according to the stages. Solving can also be done on some of its elements to get accurate results. In the AHP method, criteria can usually be arranged in a hierarchical form with leveling levels.

The criteria and sub-criteria in this study are the parameters used by the company in selecting suppliers/partners, which were obtained from the results of distributing questionnaires to colleagues in the fleet and operations division.

In this study, the researcher took a sampling of one of the consumables on the spare parts governor auxiliary engine MV Dharma Lautan Ruby and arranged it in three hierarchical levels. Level 0 is the goal/target, namely choosing the best vendor, the first level is the criteria for selecting potential partners, level 2 is a sub-criteria which is an elaboration of the first level (criteria), while level 3 is an alternative partner that must be chosen. Level 1, the criteria for selecting partners are as follows:

a) Quality
b) Price
c) Warranty
d) Delivery time

Level 2, the sub-criteria to describe each of the criteria points above are as follows:

a) Sub criteria for quality
   1. (A1) Original spare parts with certificate from the original manufacturer
   2. (A2) OEM spare parts with certificates from non-original manufacturers
   3. (A3) Fabricated spare parts without certificate
b) Sub criteria for price
   1. Below owner estimate price (20%)
   2. Same with owner estimate price
   3. Above owner estimate price (20%)
c) Sub criteria for warranty
   1. No guarantee
   2. Warranty 1-3 months
   3. 4-6 months warranty
d) Sub criteria for delivery time
   1. 1-3 days
   2. 4-7 days
   3. 8-14 days
   4. 15-30 days

Level 3 is an alternative level, namely the vendor, for this research the researcher will take a sampling of the vendor selection process for the procurement of consumer goods. There are 3 alternative candidates or vendors that will be processed, including PT DMI, PT SPM, and PT KMI, which will then be selected based on the AHP method which will begin with a hierarchy of plans for selecting the best vendor, which can be seen in the image below:

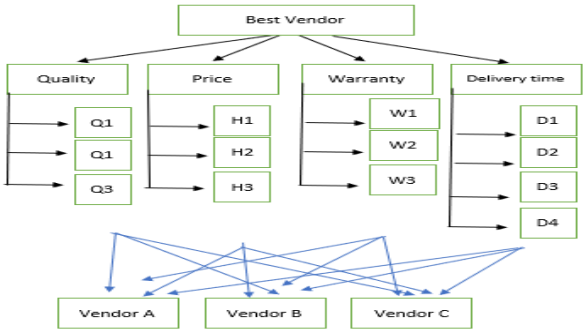

Figure 1: Hierarchical structure of problem mapping

III. RESULT & DISCUSSION

3.1 Calculation of the Weight of Each Variable Level 1

Based on the data obtained from the questionnaire given by 5 respondents by the required number of the total population of 8 respondents. From the results of the calculation of pairwise comparisons between variables in selecting vendors, the weights for all level 1 criteria are shown in the following table.

Table 4: Weighting criteria vendor selection

Criteria	Global Weight	Priority / Rank	%
Quality	0,265	II	26,5
Price	0,194	IV	19,4
Warranty	0,30	I	30
Delivery Time	0,242	III	24,2
Inconsistency			0,00347

3.2 Global priority and sensitivity

Sensitivity analysis is fundamental in the multi-criteria decision-making (MCDM) selection method to measure the stability of choosing the optimal solution if there are changes in several parameters, this is reflected in the figure below:

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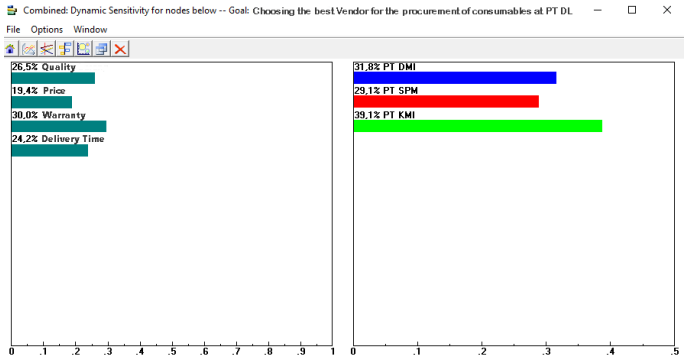

Figure 2: Dinamic sensitivity

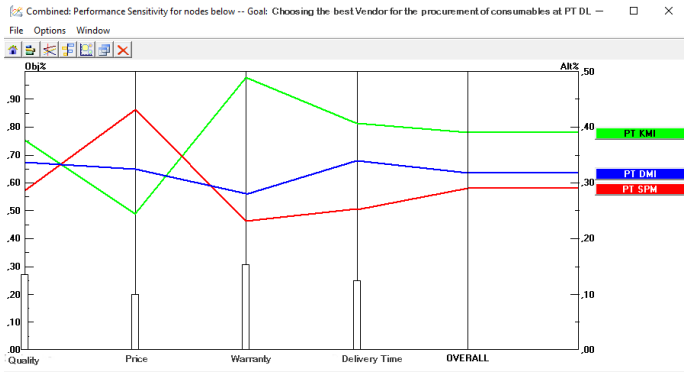

Figure 3: Performance sensitivity

From the above calculation, overall, each criterion is obtained with the following weight values:

Table 5: Global priority based on calculation expert choice

Global priority based on calculation expert choice				
Level 0	**Level 1**	**Level 2**	**Alternative**	**Global Weight**
a	Quality 0,265	Original spare parts with certificate from the original manufacturer 0,545	PT DMI	0,239
			PT SPM	0,188
			PT KMI	0,573
		OEM spare parts with certificates from non-original manufacturers 0,276	PT DMI	0,441
			PT SPM	0,357
			PT KMI	0,202
		Fabricated spare parts without certificate 0,179	PT DMI	0,401
			PT SPM	0,394
			PT KMI	0,205
b	Price 0,194	Below owner estimate price 20% 0,335	PT DMI	0,272
			PT SPM	0,527
			PT KMI	0,201
		Same with owner estimate price 0,483	PT DMI	0,389
			PT SPM	0,419
			PT KMI	0,192
		Above owner estimate price 20% 0,182	PT DMI	0,291
			PT SPM	0,176
			PT KMI	0,532
c	Warranty 0,300	No guarantee 0,147	PT DMI	0,23
			PT SPM	0,516
			PT KMI	0,255
		Warranty 1-3 months 0,247	PT DMI	0,332
			PT SPM	0,294
			PT KMI	0,374
		Warranty 4-6 months 0,606	PT DMI	0,315
			PT SPM	0,139
			PT KMI	0,546
d	Delivery time 0,242	1-3 days 0,497	PT DMI	0,233
			PT SPM	0,127
			PT KMI	0,64
		4-7 days 0,243	PT DMI	0,558
			PT SPM	0,191
			PT KMI	0,252
		8-15 days 0,153	PT DMI	0,363
			PT SPM	0,424
			PT KMI	0,214
		16-30 days 0,107	PT DMI	0,226
			PT SPM	0,626
			PT KMI	0,149

3.3 Results of Weighting Criteria, Sub-Criteria and Alternatives

The criteria that the company considers in selecting vendors in the procurement of consumer goods are quality, price, warranty, and delivery time. The weight of each criterion, namely the quality criterion weights 0.265, the price criterion weights 0.194, the warranty criterion weights 0.300, and the delivery time criterion weights 0.242. From the results of the weighting assessment, the most prioritized criterion is the warranty criterion because it has the greatest weight. The weight of each alternative is also calculated for each criterion and sub-criteria.

From the calculation of the weights of all alternatives, it is found that PT DMI weights 0.318, PT SPM has a weight of 0.291, and PT KMI has a weight of 0.391. With these results, the most prioritized alternative is PT KMI because it has the highest rating weight.

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Table 6: Final result weighting alternatives and priorities

Alternative	Global Weight	Priority / Rank	%
PT DMI	0,318	II	31,8
PT SPM	0,291	III	29,1
PT KMI	0,391	I	39,1

IV. CONCLUSION

This paper is based on the research objectives and research results above, objectively from the overall global weight calculation of each vendor, the one who gets the highest weight is PT KMI. Followed by PT DMI, and finally PT SPM. From each alternative weight calculation on alternative, the results show that PT DMI gets a weight of 0.318, PT SPM gets a weight of 0.291, and PT KMI gets a weight of 0.391. With the weight of the assessment, the most prioritized alternative is PT KMI because it obtains the highest rating weight in total and from several aspects.

The criteria that have been used as requirements in the selection of vendors for one of the procurements of consumables to support the performance of PT Djakarta Lloyd's fleet include the criteria for quality, price, warranty, and delivery time. These criteria weight according to the results of the study, namely the quality criterion weight of 0.265, the price criterion weight of 0.194, the warranty criterion weight of 0.300, and the delivery time criterion weight of 0.242. From the results of the weight assessment, the most prioritized criterion is the warranty criterion because it has the greatest weight to be able to win the competition in the procurement process without neglecting other aspects of the factors where these factors are no less important.

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