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Decision Support System for Priority Determination of Order Services Using Analytical Hierarchy Process (AHP) and Technique Order Performance By Similarity (TOPSIS)

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Abstract:

The company's growth rate from year to year can be traced to increasing product orders to companies. It causes the company to be able to provide the best service in order fulfillment or other words, must be able to be faster in prioritizing service fulfillment orders for customers. As for frequent complaints from internal or external companies. This study applies the Analytical Hierarchy Process (AHP) and Technique Order Performance By Similarity (TOPSIS) Method to determine the priority of order fulfillment services. The dataset is obtained from sales transaction data for January 2015 to December 2017. The priority of services is based on six criteria, namely, type of customer, order amount, order response, order routine, maturity receivables, and the number of returns. The test results of the software quality with DeLone-McLean model on the DSS applications that are produced indicate that the information quality is 89.50%, the system quality is 90%, the service quality is 89.33%, intention to user is 90.00%, user satisfaction is 89%, and the net benefit aspect is 94%. Overall, the average value of software quality testing is 90.78%, which is included in the Excellent category.

Keywords —**decision support system, AHP, TOPSIS, data mining, product orders.**

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I. INTRODUCTION

This research was conducted at a company that produces products in the cosmetics field. For simplicity, we called it XYZ. The XYZ company always prioritizes customers both from individuals and business entities. Customer satisfaction is an essential thing for the company because it can affect the number of product sales. With the development of the company, the number of customers also increases. At present, the company has difficulty determining priorities in meeting the demand for goods from customers. Priority determination is essential, so that customer satisfaction increases.

Determination of inappropriate product fulfillment priorities causes several problems, first of all, frequent complaints from customers about the length of service to fulfill customer orders. Furthermore, prioritizing improper order fulfillment services can also lead to conflict. Finally, the lack of transparency in the process of prioritizing order fulfillment services can cause disappointment for customers.

Based on the above problems, a decision support system was developed to prioritize order fulfillment services. The method used in the development of DSS is the AHP and TOPSIS methods. AHP method is a multi-criteria decision-making method[1], [2].AHP method is used to optimize the weight of each criterion used in DSS. This method has been used in several previous studies to solve various problems, for example for determining the priority of developing small and medium industries in Jepara[3], selection of outstanding students[4]and determining the best employees[5].

Furthermore, the AHP method is combined with the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method. The TOPSIS method is based on the concept that the best-chosen alternative not only has the shortest distance from a positive ideal solution but also has the longest distance from the negative ideal solution. TOPSIS method can help the optimal decision-making process to solve decision problems practically. This is because the concept is simple and easy to understand; its computation is efficient and can measure the relative performance of decision alternatives in a simple mathematical form [6].

In this study, we used six criteria, namely, type of customer, order amount, order response, order routine, maturity receivables, and the number of returns. The dataset is obtained from sales transaction data for January 2015 to December 2017.With this research, the DSS application developed can solve the problems experienced by the company, especially in determining the priority of fulfilling customer orders.

II. LITERATURE STUDY

A fast and good decision-making process requires a decision support system. Decision support systems are systems that are oriented towards real solutions[7]. SAW, AHP, and TOPSIS are the most widely used methods[7].With a decision support system, it can provide information, modeling, and manipulation of data to assist in making the right decisions on any structured, semi-structured, and unstructured data.For example, in research by [8]trying to help decision-making acceptance of laboratory assistants using the AHP-TOPSIS method.

Meanwhile, Kaluku and Pakaya[9] conducted a study that compared the AHP-TOPSIS and ANP-TOPSIS methods to assess the quality of HR in Gorontalo, Indonesia. The results show that the AHP-TOPSIS method produces better assessment recommendations.

Analytical Hierarchy Process or AHP is a decision support model developed by Thomas L. Saaty [1]. This decision support model will describe complex multi-factor problems or multi-criteria into a hierarchy. According to Saaty[1], hierarchy is defined as a representation of a complex problem in a multi-level structure where the first level is the goal, then followed by the factor level, criteria, sub-criteria, and so on down to the last level of the alternative. With hierarchy, a complex problem can be broken down into groups of groups which are then organized into a hierarchical form so that the problems will appear more structured and systematic.

Furthermore, the Technique Order Performance by Similarity (TOPSIS) method is a multicriteria decision-making method. The TOPSIS method assumes that each criterion will be maximized or minimized. Therefore the value of the positive ideal solution and the negative ideal solution of each criterion are determined, and each alternative is considered from that information. Also, the TOPSIS method uses the principle that the chosen alternative must have the longest distance or farthest from the negative ideal solution from a geometric point of view using the relative proximity of an alternative [10].

Positive ideal solutions are defined as the sum of all the best values that can be achieved for each attribute, while the negative ideal solution consists of all the worst values achieved for each attribute. However, positive ideal solutions are rarely achieved when solving problems in a real case.

III. METHODOLOGY

This study, we develop a decision support systems determine service order priorities using AHP and TOPSIS method. The Analytical Hierarchy Process is a method that breaks down a situation complex, unstructured, into parts of its components; organize parts or variables this in a hierarchy, giving a numeric value to subjective considerations about relative importanceeach variable and synthesize variousthese considerations to determine which variablewho has the highest priority and actsto influence the outcome of the situation [11].

In this case, the data collection uses Purposive Sampling[12] method. It is a sampling technique with not based on random, regional, or strata, but based on the existence of considerations that focus on specific goals. The purposive word means intentionally, so if interpreted, purposive sampling means the technique of purposive sampling from the data source to be studied.

IV. RESULT AND DISCUSSION

A. The Criteria Determination.

Priority criteria for order fulfillment services that are used as the basis for analyzing pending orders at PT XYZ are conducted through interviews with operational directors and managers. From the results of these interviews, several criteria were set in determining the priority of order fulfillment services as presented in Table 1.

TABLEI.
CRITERIA FOR FULFILLING ORDERS

ID	Criteria	Source	Type
C1	Customer type	Company	Benefit
C2	Number of Orders	Company	Benefit
C3	Response to the order	Company	Cost
C4	Order Routines	Company	Benefit
C5	Amount of Returns	Company	Cost
C6	Receivables Due	Company	Cost

The criteria for prioritizing the order fulfillment services above are explained as follows:

*1) **Customer Type.***The type of customer is a grouping of customers based on management evaluation results at the end of the year by marketing superiors. Evaluation is done to find out the customers who have contributed to the company. The types of customers are divided into two types, namely, strategic customers and regular customers. Strategic customers are customers who are supervised by companies precisely because they have an outstanding contribution to the company and are supported by senior marketing. While Regular customers are customers whose contributions to the company are still not excellent based on their purchase history. Regular customers are usually still supported by junior marketing.

*2) **Number of Orders.***The order amount is the quantity of product ordered by the customer to the company. The number of orders is significant to the costs incurred by the company because the more quantity ordered, the smaller the costs incurred for the company's operations. Conversely, if the smaller the order quantity, the higher the costs incurred for operations.

*3) **Response to the order.*** Order response is the time of order input (date and time) by marketing to the current sales system.

*4) **Order Routines.*** Order routines describe how often customers make orders. Customers who order every month are considered as customers who regularly order. Conversely, it is considered not routine.

*5) **Amount of Returns.*** The number of returns is the return of the product from the customer to the company because the product is not as expected by the customer, for example, due to product defects. Every product that is moved by company calculation will be reduced in value from the product.

*6) **Receivables are due.***Overdue receivables are customers who have receivables that are due. On accounts receivable due to the value of non-determined receivables, which is essential if there is a large or small amount of receivables, it is categorized as maturity receivables.

B. The Calculation of Criteria Weights using AHP Method.

The first step is to weight the criteria. Calculation of the weighting criteria for prioritizing order fulfillment services using the AHP method is explained below.

*1) **Make a paired comparison matrix.*** Table 2 presents a paired comparison matrix for each criterion. Comparison of each criterion is determined based on the results of interviews and discussions with the leadership of the company.

TABLEII
PAIRED COMPARISON MATRIX

Criteria	C1	C2	C3	C4	C5	C6
C1	1	3	5	7	9	9
C2	1/3	1	3	5	7	9
C3	1/5	1/3	1	3	5	7
C4	1/7	1/5	1/3	1	3	5
C5	1/9	1/7	1/5	1/3	1	3
C6	1/9	1/9	1/7	1/5	1/3	1

*2) **Normalization of the criteria value matrix.*** Normalization of the weight values is done to keep the weight values at a particular range. Normalization is done by equation (1). The results of normalization can be seen in Table 2.

$$Fi = \sqrt[n]{\prod_{j=1}^{n} a_{ij}} \quad (1)$$

TABLEIII.
THE RESULTS OF NORMALIZATION

Criteria	C1	C2	C3	C4	C5	C6	Fi
C1	1	3	5	7	9	9	4.518
C2	0.333	1	3	5	7	9	2.608
C3	0.2	0.333	1	3	5	7	1.383
C4	0.143	0.2	0.333	1	3	5	0.723
C5	0.111	0.143	0.2	0.333	1	3	0.383
C6	0.111	0.111	0.143	0.2	0.333	1	0.221
Total	1.898	4.787	9.676	16.533	25.333	34	9.837

*3) **Calculate the criteria weight.*** The criteria weight is the average value of the criteria which can be calculated by dividing the number of the value of the comparison matrix of each criterion by the number of criteria. From the normalized matrix results (Table 2), we calculate the criteria weight by equation (2). The results of the weight calculation for each criterion can be seen in Table 4.

$$Pi = \frac{Fi}{\sum_{i=1}^{n} Fi} \quad (2)$$

TABLEIV
THE WEIGHT OF EACH CRITERION

Criteria	C1	C2	C3	C4	C5	C6	Pi
C1	1	3	5	7	9	9	**0.459**
C2	0.333	1	3	5	7	9	**0.265**
C3	0.2	0.333	1	3	5	7	**0.141**
C4	0.143	0.2	0.333	1	3	5	**0.073**
C5	0.111	0.143	0.2	0.333	1	3	**0.039**
C6	0.111	0.111	0.143	0.2	0.333	1	**0.025**
Total	1.898	4.787	9.676	16.533	25.333	34	1

*4) **Calculation of consistency ratio values.*** The calculation of Consistency Ratio (CR) is done to determine whether the weighting of criteria carried out based on user preferences is consistent or not. If the CR value is less than 10%, then the weighting is considered consistent and acceptable. Calculation of CR value follows several calculation steps. First of all, calculate the weighted number by multiplying the value of Pi and the total value for each criterion. Second, calculate the λ max value by summing the weighted number of all criteria. Third, calculate the value of the Consistency Index (CI) with Equation (3). Fourth, calculate the value of Consistency Ratio (CR) with Equation (4). In this study, six criteria were used, so the value of the Random Index (RI) was 1.24 [13]. Based on the results of calculations, the value of λ max of 6.469 is obtained, the CI value is 0.094, so the CR value is 0.075. CR value <10%, meaning the weight of criteria can be accepted and valid.

$$CI = \frac{\lambda_{max} - n}{n - 1} \quad (3)$$

$$CR = \frac{CI}{RI} \quad (4)$$

Based on the weighting carried out using the AHP method, we obtained the weight of each criterion as presented in Table 4. The criteria for customer type (C1) is 0.459, number of orders (C2) is 0.265, response to orders (C3) is 0.141, order routines (C4) is 0.073, amount of returns (C5) is 0.039, and due receivables (C5) is 0.025.

C. Ranking with the TOPSIS method

After weighting for each criterion, then an alternative value is calculated using the TOPSIS method. From the calculation results, a ranking is performed to get customer priority recommendations.The first step to do ranking with the TOPSIS method is to evaluate all alternatives, which in this study is an alternative data customers who place an order to the company.The assessment process for each alternative is carried out for each assessment criteria. Assessment is carried out by following the rules presented in Table 5. Furthermore, Table 5 also presents the scores for each set of values. The range of the scores is between 0-10.

TABLEV.
THE VALUE SETS AND ITS SCORE

#	Criteria	Value Sets (Score)
C1	Customer type	• STRATEGIC (10) • REGULAR (5)
C2	Number of Orders	• < =100 (1) • 101 - 200 (2) • 201-300 (3) • 301 – 400 (4) • 401 – 500(5) • 501 – 600(6) • 601 – 700(7) • 701 – 800(8) • 801 – 900(9) • > 900 (10)
C3	Response to the order	• < = 1440 (1) • 1441 – 2880 (2) • 2881 – 5760 (3)

		• 5761 – 11520 (4) • 11521 – 23040 (5) • 23041 – 46080 (6) • 46081 – 92160 (7) • 92161 – 184320 (8) • 184321 – 368640 (9) • > 368640 (10)
C4	Order Routines	• ROUTINE (10) • NOT ROUTINE (5)
C5	Amount of Returns	• NOT EXIST (10) • EXIST (5)
C6	Receivables Due	• NOT EXIST (10) • EXIST (5)

For example,they are ranking with TOPSIS, in Table 6 presented five customer data along with the values of each criterion. Customer data is encoded into A1, A2, A3, A4, and A5.Furthermore, the original values of each of these criteria are converted according to the rules in Table 5 so that the values are in the range 1-10.

TABLE VI.
EXAMPLES OF ALTERNATIVE DATA AND THEIR VALUES

Alternative	C1	C2	C3	C4	C5	C6
A1	STRATEGIC	1150	13582	ROUTINE	NOT EXIST	NOT EXIST
A2	STRATEGIC	130	31029	ROUTINE	EXIST	NOT EXIST
A3	STRATEGIC	140	8005	ROUTINE	EXIST	NOT EXIST
A4	STRATEGIC	20	19388	ROUTINE	EXIST	NOT EXIST
A5	REGULER	50	16804	ROUTINE	EXIST	NOT EXIST

Table 7 presents alternative values that have been converted based on the rules in Table 5. After the value is converted, then normalized values are calculated using Equation (3). Normalized values are obtained by dividing the alternative value (a_{ij}) with the root of the sum of the squares of the overall value.

TABLE VII.
THE CONVERTED ALTERNATIVE VALUES

Alternative	C1	C2	C3	C4	C5	C6
A1	10	2	9	10	10	10
A2	10	3	7	10	5	10
A3	10	1	7	10	5	10
A4	10	2	7	10	5	10
A5	5	1	7	10	5	10

$$P_{ij} = \frac{a_{ij}}{\sqrt{\sum_{j=1}^{n} {a_{ij}}^2}} \quad (3)$$

Table 8 presents alternative values that have been normalized so that all values are in the range 0-1.Next, the normalized value is multiplied by the weight of each criterion, resulting in a weighted value (*r*). The weight of each criterion (*Pi*) is calculated using the AHP method and can be seen in Table 4. The calculation results for each alternative value are presented in Table 9.

TABLE VIII.
THE NORMALIZED ALTERNATIVE VALUES

Alternative	C1	C2	C3	C4	C5	C6
A1	0.45	0.09	0.41	0.45	0.45	0.45
A2	0.45	0.14	0.32	0.45	0.23	0.45
A3	0.45	0.05	0.32	0.45	0.23	0.45
A4	0.45	0.09	0.32	0.45	0.23	0.45
A5	0.23	0.05	0.32	0.45	0.23	0.45

TABLEIX.
THE RESULTS OF THE MULTIPLICATION OF THE NORMALIZED ALTERNATIVE VALUES AND THE CRITERIA WEIGHT

Alternative	C1	C2	C3	C4	C5	C6
A1	0.208	0.024	0.058	0.033	0.018	0.011
A2	0.208	0.036	0.045	0.033	0.009	0.011
A3	0.208	0.012	0.045	0.033	0.009	0.011
A4	0.208	0.024	0.045	0.033	0.009	0.011
A5	0.104	0.012	0.045	0.033	0.009	0.011

After obtaining a weighted normalization value as in Table 9, it is determined the ideal positive solution (S^+) and the ideal negative solution (S^-). If the criteria include the type of benefit criteria, then the ideal positive solution is the highest value of all alternative values, and vice versa, if it includes the types of cost criteria, then the ideal positive solution is the smallest value of all alternative values. For an ideal negative solution, the opposite applies. If the benefit criteria are included, the value is obtained from the smallest value, and if it includes the cost criteria, the value is obtained from the highest value.

TABLEX.
IDEAL POSITIVE SOLUTIONS (S^+) AND NEGATIVE IDEAL SOLUTIONS (S^-)

Alternative	C1	C2	C3	C4	C5	C6
S^+	0.208	0.036	0.045	0.033	0.009	0.011
S^-	0.104	0.012	0.058	0.033	0.018	0.011

Based on the value of the positive ideal solution (S^+) and the negative ideal solution value (S^-) in Table 10, the next step is to calculate the distance between alternative values with positive ideal values (S^+) and negative ideal values (S^-). Distance calculation is done by Equation (4) for positive distance (D^+) and Equation (5) for negative distance (D^-).After positive ideal distance and negative ideal distance are obtained, the next preference value (V) is calculated for each alternative by Equation (6).The results of the calculations are presented in Table 11.

$$D_i^+ = \sqrt{\sum_{j=1}^{n} (r_{ij} - S_j^+)^2} \quad (4)$$

$$D_i^- = \sqrt{\sum_{j=1}^{n} (r_{ij} - S_j^-)^2} \quad (5)$$

$$V_i = \frac{D_i^-}{D_i^+ + D_i^-} \quad (6)$$

TABLEXI.
VALUE OF PREFERENCE WEIGHT (V) OF EACH ALTERNATIVE.

Alternative	D+	D-	V
A1	0.020	0.105	0.842
A2	0.000	0.108	**1.000**
A3	0.024	0.105	0.814
A4	0.012	0.106	0.898
A5	0.107	0.016	0.127

Based on the preference value (V) in Table 11, it can be concluded that A2 customers get the first order service priority because it has the highest value. In order, the priority for fulfilling orders from these data is A2, A4, A1, A3, and A5.

D. DSS Development

In this study, a DSS application was developed that implemented the AHP-TOPSIS method. DSS application development aims to facilitate PT XYZ in determining the priority of fulfilling customer orders. Application users can manage customer data, criterion data, weight, to do calculations, and to rank. Figure 1 shows an example of a criteria data management page, while Figure 2 shows an example of a criteria weighting page.

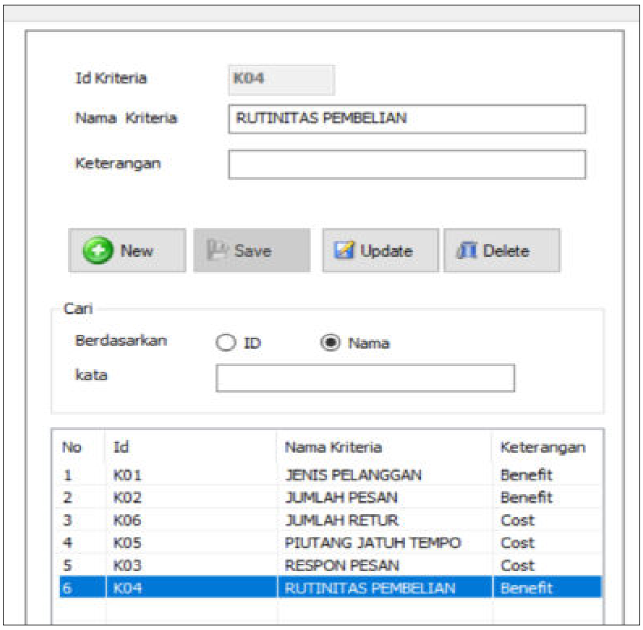

Fig. 1The Criteria data management page

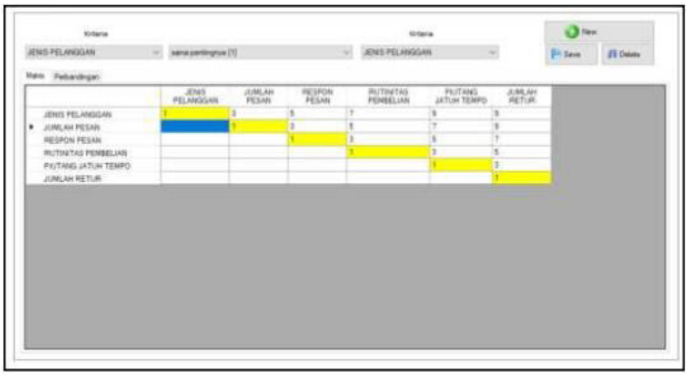

Fig. 2 The Criteria weighting page

To measure the quality of the DSS application produced in this study, we measured software quality with the DeLone-McLean information system success model[14]. The aspects assessed are information quality, system quality, service quality, the intention to use, user satisfaction, and net benefits.

The assessment of the quality of information systems is carried out through a questionnaire instrument filled by eleven respondents using the application. Table 12 presents the results of the assessment of application users for each aspect assessed. From the table the results of the information quality aspect assessment are 89.50%, system quality is 90%, service quality is 89.33%, intention to use is 90%, user satisfaction is 89%, and benefits aspects are 94%. Thus, the overall value of software testing using the DeLone-McLean method is 90.78%, which means that overall, the quality of this system is in the excellent criteria.

TABEL XII.
THE RESULTS OF QUALITY INFORMATION SYSTEM TESTING WITH DELONE-MCLEAN

#	Quality Aspects	Ideal Score	Actual Score	% of Actual Score	Meaning
1	Information Quality	200	179	89.50	Excelent
2	System Quality	150	135	90.00	Excelent
3	Service Quality	150	134	89.33	Excelent
4	Intention to use	50	45	90.00	Excelent
5	User Satisfaction	100	89	89.00	Excelent
6	Net Benefit	250	235	94.00	Excelent
	Total	**900**	**817**	**90.78**	**Excelent**

V. CONCLUSIONS

Based on the discussion of the results of the research discussed in the previous chapter, some conclusions are obtained. First of all, the results of developing AHP-TOPSIS DSS modelscan help the company in giving priority recommendations to fulfill customer orders. Next, the implementation of decision support systems prioritizing order fulfillment services with the AHP-TOPSIS method provides transparency in the process of prioritizing order fulfillment services. Finally, testing of the software quality with DeLone-McLean model on six aspects of assessment resulted in an average value of 90.78%. This value is in an excellent category.

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