Decision Support System of Warehouse Allocation using Analytical Hierarchy Process Method

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Abstract: This study aims to improve business processes by developing an innovation that can support the determination of warehouse allocation decision making. The delay in determining the decision to allocate the warehouse is the main reason for this research. The analysis process until the distribution of information is not systematic so that it slows the distribution process. This research develops an information system that can automate the determination of warehouse allocation decisions using Analytical Hierarchy Process (AHP) data processing methods that can be sorted by the ranking of the proposed alternatives. The results showed that the solution could accelerate the process of warehouse allocation so that the distribution process runs more optimally.

1 INTRODUCTION

The rapid development of today's technology invites the attention of various industrial sectors to utilize information system technology. Information systems have become one of the basic needs that support almost all company activities. No exception in trading companies, information systems will significantly assist them in the process of distributing goods to consumers(Dennis et al., 2012). A critical process in a company is the decisionmaking process. Making decisions is part of the process of considering, understanding, remembering and reasoning about everything Decisions are taken by knowing and formulating the problem clearly, then solving the problem must be based on the selection of the best alternative decisions. Because of the importance of this decisionmaking process, which decisions must be taken quickly and accurately, the Decision Support System (DSS) information system appears. This decision support system is an information system which helps company management to be able to make decisions more quickly and accurately. This system combines various data in the company, calculates and processes it soon until finally, it produces information that will help in the decision-making process. This company has 3 leading warehouses spread across the Jakarta-Tangerang area, namely in Cimanggis, Jatake (fig.1), Jatiasih (fig.2)

Figure 1: Distribution to Jatake

Figure 2: Distribution to Jatiasih

The allocation process is still running using WhatsApp (fig.3) assistance and occurs outside the analyst distribution work hours, which is at 6 pm. So, it can be said that the running process can take up time because the distribution of analysts takes approximately 7-10 minutes to analyse the data. Besides that, the use of Microsoft Excel in analysing data manually allows for human error. On the other hand, the destination warehouse decision information must be fast and accurate so that PIC Shipping is immediately followed up and distributed to drivers for delivery. The slower the flow of information will undoubtedly affect the

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speed of the process of distributing goods. This will ultimately have an impact on the company's business processes, so companies need a system that can support the process of analysing the allocation of warehouse destinations quickly and precisely.

Figure 3: Allocation process using WhatsApp

This is where the role of decision support systems is expected to help the organization. With the adoption of a decision support system, the data analysis process to determine the destination warehouse is scheduled to run more quickly and systematically and can reduce the burden of analysis on analyst distribution. With this author raised the idea to Analysis and Develop Information Systems Supporting Warehouse Allocation Decisions using AHP (Mu and Pereyra-Rojas, 2016)(Saaty, 2008). AHP methods related to DSS have been widely used and proven to provide benefits for companies (Susanto et al., 2017).

2 LITERATURE REVIEW

2.1 Decision Support System

Decision Support System (DSS) is a computer-based decision support tool to assist decision-makers by presenting information and interpretations for various alternative decisions (Pal and Palmer, 2000). The aspect of the scope system in DSS is automation which helps decision-makers with different levels of intelligence. From a theoretical point of view, decisions relate to cognitive concepts, especially those related to ideas that support humans in decision making. SPK can help decision-makers in building strategic decisions. The use of DSS has shown satisfactory results, by minimising costs, accelerating the decision-making process, and significant achievements in competitive advantage.

2.2 Analytic Hierarchy Process

The Analytic Hierarchy Process (AHP) developed by Professor Thomas Saaty in 1980 made it possible to arrange decisions hierarchically (to reduce their complexity) and show the relationship between goals (or criteria) and potential alternatives (Mu and Pereyra-Rojas, 2016), the stages carried out refer to the analytic hierarchy process:

1. Develop a model for decisions: Break the decision into a hierarchy of goals, criteria, and alternatives
2. Lower the priority (weight) for the criteria
3. Consistency
4. Lower local priorities (preferences) for alternatives
5. Decrease Overall Priority (Synthesis Model)
6. Do a sensitivity analysis
7. Make Final Decisions.

2.3 Previous Research

The Yager Fuzzy MADM model chosen as the Yager analysis model to determine the most prospective customers with better feasibility through the highest giving(Susanto et al., 2017). By using the vector D value that has been calculated from the sum of each criterion value {0.904; 0.794; 0.914; 0.794}, the most prospective customers are customers C (D3) with a value of 0.914.

The customer is chosen as the most prospective customer to be given Murabahah financing. Each criterion is given a weight value according to the desired priority. The system that was built streamlined the decision-making process time to be more efficient. DSS generates valuation calculations based on subjective and objective assessment criteria for using 5C: Character, Capacity, Capital, Guarantee and Conditions. The system can present an assessment based on the calculation of the value of each criterion such as very good with a value of 1, 0.8, 0.6, 0.4 and 0.2 to improve the weight vector results obtained from the input value of the comparison criteria to produce the most recommended customer data sequence. The success of AHP on DSS was also carried out by other researchers with different achievements according to their individual needs (Dweiri et al., 2016) (Sari et al., 2017)(Narabin and Boonjing, 2016).

Another researcher is by (Sinesi et al., 2017) generating DSS with A multivariate logic to monitor in real-time for one week using GPS data from MarineTrafficwebsite and validating the proposed model by comparing the results of the model with real data which counts four performance indicators (ME, MAD, MAPE, MSE), the accuracy results are better than the proposed model in evaluating the probability of a maritime company choice.

From the literature that the author studied before, there are some similarities and also differences. The equation is that the above writing together aims to create solutions in determining decisions of the issues raised, whereas the difference is in terms of methodology and technique.

From the literature above, it is explained some use the Fuzzy, Fuzzy MADM and AHP methods. From the differences and similarities above, the author can conclude that the research the writer raised is similar to the 5th study(Narabin and Boonjing, 2016), which together use the AHP methodology for decision making. This is because decision making has multi-criteria decision making, so ranking techniques are needed to determine the best. From our observation, the AHP methodology is judged to be following the present case.

The AHP methodology itself was developed by Thomas Saaty, in which decision making is calculated by placing priority scores in the form of a criteria matrix, then calculating choices, and finally getting a percentage of each option. The best choice is the priority score with the highest percentage. The authors chose the AHP method because it has a clear hierarchical structure so that it will be able to reduce complexity and be able to show a clear relationship between the criteria and alternative solutions proposed.

3 RESULT AND DISCUSSION

Of the 11 stages of the business process running, the authors find 8 steps that allow the process to be maximized. And, we found 6 stages of the process that runs the system running namely:

1. In the PIC Shipping WMS interface, shipping data is mixed between those that have not been allocated, those that have been awarded, or those that have been verified by the warehouse. And not grouped by expedition fleet police and plant number.
2. The waiting time for submitting summary shipping list information from PIC Shipping to analyst distribution is still quite long, which is around 2-3 minutes. This happens because the delivery of information is still going on using the help of WhatsApp
3. The analysis process always takes about 7-10 minutes because it is done manually by the distribution analyst utilising the support of a simple application, thus allowing input errors or analysis errors.
4. There is still a dependence on the presence of Analysts Distribution. So if the distribution analyst is not carrying a smartphone (to check WhatsApp), it will hamper the distribution process.
5. There are 2 shipping shifts from AHM, while there are only 1 analyst distribution staff, so the workload of 1 distribution analyst can reach 15 hours per day, in 5 working days.
6. There are times when there is still a suboptimal balance of stock in each warehouse, due to uneven allocation.

The stages of using AHP techniques in this study are as follows:

1. Modelling
   Here the criteria are determined which are used as a reference for problem analysis. Measures that have been obtained from the results of interviews with respondents, then evaluated and can be described with the following hierarchy (in Indonesian according to company needs)

Figure 4: Decision Hierarchy

2. Determine priorities (weights) for the criteria
   The next step in the AHP process is to determine the priority (weight) for each standard. This is done to measure the importance of the requirements and then compare with each other. This process requires a direct assessment of the respondent, namely the distribution of analysts, who are most knowledgeable about how each of these criteria is applied. As a basis for each weighting, we use the reference scale set, as the basis for AHP weighting. And produce it seen in fig. 6.

Verbal judgment	Numeric value
Extremely important	9
	8
Very Strongly more important	7
	6
Strongly more important	5
	4
Moderately more important	3
	2
Equally important	1

Figure 5: Pairwise comparison scale (Dweiri et al., 2016)

	Expeditionary Fleet	Distribution Achievement	Warehouse Needs	Warehouse Capacity	Distance
Expeditionary Fleet	1.00	5.00	5.00	7.00	9.00
Distribution Achievement	0.20	1.00	1.00	5.00	7.00
Warehouse Needs	0.20	1.00	1.00	3.00	5.00
Warehouse Capacity	0.14	0.20	0.33	1.00	3.00
Distance	0.11	0.14	0.20	0.33	1.00
Sum	1.65	7.34	7.53	16.33	25.00

Figure 6: Pairwise comparison matrices obtained

The next stage, the normalisation process is derived from the results of the delivery with the value of SUM. For example the Expeditionary Fleet on the Expeditionary Fleet 1.00 / 1.65 = 0.60. (See fig.7). After obtaining a complete normalization matrix, the next step is to add priority vector columns, which are derived from the total results of each row divided by the number of criteria.

	Expeditionary Fleet	Distribution Achievement	Warehouse Needs	Warehouse Capacity	Distance	Priority Vector
Expeditionary Fleet	0.60	0.68	0.66	0.43	0.36	0.55
Distribution Achievement	0.12	0.14	0.13	0.31	0.28	0.20
Warehouse Needs	0.12	0.14	0.13	0.18	0.20	0.15
Warehouse Capacity	0.09	0.03	0.04	0.06	0.12	0.07
Distance	0.07	0.02	0.03	0.02	0.04	0.03

Figure 7: Normalised matrix

So we get the results of the direct assessment of the respondents in fig. 8 and the effects of priority vectors.

	Expeditionary Fleet	Distribution Achievement	Warehouse Needs	Warehouse Capacity	Distance	Priority Vector
Expeditionary Fleet	1.00	5.00	5.00	7.00	9.00	0.55
Distribution Achievement	0.20	1.00	1.00	5.00	7.00	0.20
Warehouse Needs	0.20	1.00	1.00	3.00	5.00	0.15
Warehouse Capacity	0.14	0.20	0.33	1.00	3.00	0.07
Distance	0.11	0.14	0.20	0.33	1.00	0.03

Figure 8: The results of the original weighting with priority vector

From the results of the table above it can be seen that when determining the decision of the destination warehouse, the support of the expedition fleet has the highest importance (0.55), followed by the achievement of distribution (0.20), warehouse requirements (0.15), warehouse capacity (0.07), and the lowest distance (0.03).

3. Consistency
AHP has set acceptable limits of inconsistency, namely by calculating the consistency ratio (CR) which is the result of a comparison of the consistency index (CI) of a matrix with a random matrix consistency index (RI).

$$CR = CI/RI \tag{1}$$

Acceptable inconsistencies are CRs that are less than or equal to (¡=) 0.10. If the CR is less than or equal to 0.10 (¡= 0.10), then it can proceed to the next problem analysis stage, but if more than 0.10, then a revision must be made whether the assessment is really appropriate. The stage taken is to multiply the grading matrix with the priority vector. After the priority vector and weighted sum are obtained, the next step is to add the result of division which is the result of the division between weighted sum and priority vector (see fig. 9)

	Expeditionary Fleet	Distribution Achievement	Warehouse Needs	Warehouse Capacity	Distance
Weighted Sum	3.08	1.04	0.84	0.34	0.18
Priority Vector	0.55	0.20	0.15	0.07	0.03
Result of Division	5.63	5.34	5.41	5.03	5.1

Figure 9: weighted sum, priority vector, and effect of division

$$\begin{aligned} \lambda max &= SUM(theresultofdivision) \\ &= (5.63+5.34+5.41+5.03+5.1)/5 \\ &= 5.302 \\ CI &= (\lambda max–n)/(n–1) \\ &= (5.302-5)/(5–1) \\ &= 0.075 \\ CR &= CI/RI \\ &= 0.075/1.11 \\ &= 0.068 \end{aligned} \tag{2}$$

From the above calculation, a consistency ratio of 0.068 is obtained. This shows that CR is less than 0.1, so it can be concluded that the assessment/weighting has been done consistently

4. Lower local priorities (preferences) for alternatives
The next step is about how to obtain the relative priority (preference) of each criterion. This is done by comparing the criteria against each alternative (pairwise comparison). Here the writer takes data samples from the distribution analyst shipping list on April 18, 2019, with fleet police number B 9499 UEH. This fleet carries only 1 no shipping list, namely 1100/2019/12070, which contains 51 units of motorcycles. CBS 150 CBX motorcycles with 8 units of V1J2Q2S2 black (BK) code, and 43 units of white colour (WH). To which warehouse will this fleet be allocated? To determine the solution of the problem sample above, a sample of questions was conducted by

the author along with the distribution of analysts based on predetermined criteria. The results are shown in fig.10.

Distance	Value	Priority Vector
CMG	33	0,29
JTK	56	0,49
JTA	25	0,22
Sum	114	1,00

Figure 10: Preferences based on the distance of the warehouse - plant (fast way)

So we get the results of CMG with priority vector 0.29, JTK with priority vector 0.49, and also JTA with priority vector 0.22. From these figures, it can be seen that in terms of plant - warehouse distance, JTK warehouse is preferred over JTA and CMG

5. Decrease Overall Priority (Synthesis Model) After obtaining local priorities from alternatives that excel in each criterion, the next step is to calculate the overall preference for each option. From the global priority, then made the ranking, which is the result of ordering (order) from the largest to the smallest.

Warehouse	Overall Priorities	Rank
CMG	0.39	1
JTK	0.35	2
JTA	0.26	3

Figure 11: Ranking results

Because the ranking results have been obtained, the next stage is not carried out.

4 CONCLUSIONS

Conducted with distribution analysts, it was found that the proposed system can provide decision support directly to the company's PIC Shipping, so that the allocation process can run in only about 1-2 minutes, from the previous 9-13 minutes. AHP method used in the proposed system was able to provide warehouse allocation decision support with a high degree of accuracy so that the decision automation process could run well

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