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Performance Measurement of Outbound Logistics in the Fertilizer Industry for Distribution Activities Based on Performance Of Activity (POA) Model and Analytical Hierarchy Process(AHP) Method

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Abstract. This research presents problems in the fertilizer industry with the goal of knowing the performance of fertilizer distribution. The outbound logistics process in fertilizer distribution activities is important, because it is connected to the process of delivering fertilizer products to consumers. However, in carrying out fertilizer distribution activities, there are problems that occur due to the mismatch of warehouse capacity over storage and differences in estimated delivery time. This situation results in missed fertilizer supplies for consumers. This research uses KPI criteria based on the Performance Of Activity (POA) model and performance weighting with the Analytical Hierarchy Process (AHP) method to determine the value of the Company's outbound logistics performance. The discussion with company experts resulted in 12 KPI indicators based on POA criteria consisting of cost, time, capacity, capability, productivity, utility, and outcome. After weighting with the AHP method, the total outbound logistics performance of 85,918 is included in the good category and can still be improved in the excellent category by giving recommendations for improvement. So, further research can be made collaborating the AHP method with other methods such as the SCOR method to simplify the selection of supply chain process activities or using the Fuzzy AHP method to reduce the subjectivity of the research.

Keywords: AHP, Distribution, KPI, Outbound Logistics, POA, Warehouse

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1. Introduction

In its application, the agricultural sector in Indonesia is the choice of people to work as farmers who have become the main source of income for them [1]. Based on its usefulness, the demand for fertilizer increases and optimal distribution is carried out to each region. Distribution is a process used to deliver products to reach consumers. Currently, the logistics industry in the agricultural sector is the focus of an industry [2]. Outbound logistics is the process of delivering finished products to consumers through the

distribution process. In this process, the finished product is transported using transportation modes by calculating the route that will be used for transportation [3]. The use of distribution transportation modes will be adjusted to the load capacity of transportation and storage warehouses [4]. Capacity adjustment aims to determine the performance assessment of the distribution network and logistics operations, starting from the beginning of the distribution process until it stops at the final warehouse or consumer [5]. Performance measurement on the distribution process can be completed using the Performance of Activity (POA) model to measure the performance of activities in the supply chain process [6].

PT XYZ is one of the fertilizer producers in Indonesia and holds several companies involved in fertilizer production. The company has reached a production capacity of 9 million tons per year of Urea fertilizer and 3 million tons per year of NPK fertilizer. The outbound logistics process in fertilizer distribution activities starts from the fertilizer product factory, transported and sent by transportation mode to the final storage warehouse. However, in carrying out fertilizer distribution activities at the Padang warehouse in 2023, the company experienced problems in the difference between the amount of fertilizer distribution allocation and the amount of existing capacity. The capacity of the Padang warehouse filled with fertilizer products is 8 thousand tons and has been filled about 102% and the fertilizer distribution allocation is around 3%, meaning that the shipping allocation will experience an overage of about 5% of the capacity. The following is the data from the start of the allocation difference with the existing capacity from July 2023 to December 2023.

Table 1. Delivery Allocation and Existing Capacity

Month	Percentage of Allocation Amount	Percentage of Existing Capacity
July 2023	7%	56%
August 2023	2%	83%
September 2023	2%	87%
October 2023	5%	101%
November 2023	2%	60%
December 2023	3%	102%

Source: Company Data Processed

After evaluating the distribution of fertilizers, it was found that in the distribution period of October 2023 and December 2023 there was a difference of around 5%. In addition to these constraints, other unexpected fertilizer distribution constraints are problems in the delay of fertilizer delivery with an average delay of 3 to 4 days, which causes inaccurate timing of fertilizer product availability. These constraints occur due to errors in the company's distribution activity monitoring website and employee recording errors.

From the above problems, the purpose of this study is to determine the outbound logistics performance of fertilizer distribution and provide suggestions for improvement to improve the company's outbound logistics performance. One way to maximize company performance is to measure its performance [7]. Performance measurement is needed on projects or jobs in the company to increase job success [8]. Good performance measurement can predict future performance as decision making [9]. In identifying the supply chain, a performance assessment evaluation is needed [10]. One approach that can be used to measure performance is the Performance of Activity (POA) model. POA is a model for measuring performance on activities in the SC process in 7 (seven) dimensions, such as costs, time, capacity, capability, productivity, utility, and outcomes, where the seven dimensions are interconnected to improve supply chain performance in the company [11]. The application of performance measurement with the POA model will show the performance weight in each dimension. The performance weighting used in this study is based on the AHP method. Analytical Hierarchy Process(AHP) is a method used as a performance measurement tool using a scale based on pairwise comparisons [12]. In particular, AHP is commonly used as an alternative decision [13]. So, it is necessary to identify KPI indicators in order to know the value of indicators that are not optimal and can be given improvement suggestions to increase the value of Company performance [14]. This can bring changes to the industry in a company's operations will be better [15].

Performance measurement is used to improve the value of company performance. And some researchers use the Performance of Activity (POA) model to determine the performance of an organization or process with the dimensions of cost, time, capacity, capability, productivity, utility, and outcome. The novelty in this research is the use of warehouse capacity criteria and warehouse rental costs.

2. Methods

This research uses the Performance of Activity (POA) model and the Analytical Hierarchy Process (AHP) method to determine the weight of outbound logistics performance. Where outbound logistics focus on everything that happens outside the company [16].

a. Data Collection
   The data collection process of this research is by observations and direct interviews with company experts.
b. Performance of Activity (POA)
   This research uses outbound logistics performance criteria based on the 7 criteria on the POA model and namely is cost, time, capacity, capability, productivity, utility, and outcome [17]. Indicator selection criteria are among the most important in assessment [18].
c. Analytical Hierarchy Process (AHP)
   This research use AHP method to weight the POA criteria and KPI indicators that have been selected by the Company expert.
   The AHP method steps used are:
   1) Pairwise comparisons and matrix calculation
   2) Matrix normalization and calculation for maximum eigenvalue
   3) Consistency test
   4) Verify the consistency test results [19].

Based on the selection of outbound logistics performance indicators by company experts, performance indicators are obtained that are in accordance with the needs and situation within the company. As follows:

Table 2. Indicator Variables

Criteria	Indicator	Information
Cost (B)	Delivery cost	B1
	Labor cost	B2
	Warehouse rental cost	B3
	Stockholder cost	B4
Time (W)	Lead time of fertilizer inventory	W1
Capacity (KP)	Storage warehouse capacity	KP1
Capability (KB)	Vendor reliability	KB1
	Transportation optimization	KB2
Productivity (P)	Loading unloading workers	P1
Utility (UT)	Loading unloading working hours	UT1
Outcome (OC)	Sharing space	OC1
	New warehouse	OC2

Source: Data processed

In the table on top, 12 KPI indicators have been selected by company experts and can be applied to research.

3. Results and Discussion

In the results and discussion stage, the performance value will be calculated based on the POA model criteria and using the AHP method. Previous research uses the POA model for supply chain performance measurement. Vildayanti [6] and Rizkya [11] highlighted the great significance of costs in the production process to determine the efficiency of their use.

3.1. Weighting Analitical Hierarchy Process (AHP) Method

Firdantara and Setiawan [20] suggest that the AHP method is used to determine criteria and criteria weights. KPI weighting with the AHP method will be used to set the weighting of the problem criteria. The value of the weighting will be said to be consistent if the result of the consistency ratio or CR value ≤ 0.1 (10%) [21].

In the pairwise comparison matrix, the value of each indicator for the Key Performance Indicator (KPI) has been determined by company experts using a scale from number 1 to 9. Thus, the resulting weighting of POA criteria in the level 1 pairwise comparison matrix can be seen in the table below:

Table 3. Pairwise Comparison Matrix

	Cost	**Time**	**Capacity**	**Capability**	**Produktivity**	**Utility**	**Outcome**
Cost	1	1	5	7	1	5	2
Time	1	1	3	4	1	4	1
Capacity	0,200	0,333	1	1	1	0,333	1
Capability	0,143	0,250	1	1	0,200	2	0,500
Produktivity	1	1	1	5	1	4	1
Utility	0,200	0,250	3	0,500	0,250	1	0,50
Outcome	0,500	1	1	2	1	2	1
Total	4,043	4,833	15	20,500	5,450	18,333	7

Source: Data processed

After the value is calculated in the pairwise comparison matrix in the table above, then the weighting calculation for the Analytical Hierarchy Process (AHP) method is carried out on each POA criterion in the following way:

a. Normalize each criterion using the formula:

$$\text{Normalize} = \frac{\text{matrix scale value of each criteria}}{\text{total value of each criteria}} \quad (1)$$

b. Calculation of the weight value on each criterion using the formula:

$$\text{Weight Value} = \frac{\sum \text{Value in each row of criteria normalization}}{\text{amount of criteria}} \quad (2)$$

c. Calculate the maximum eigenvalue using the formula:

$$\text{Eigen value maximum} = \text{matrix scale value of each criteria} \times \text{weight value of each criteria} \quad (3)$$

d. Calculate the consistency value using the formula:

$$\text{Consictency Index (CI)} = \frac{\lambda \max - n}{n-1} \quad (4)$$

$$\text{Consistency Ratio (CR)} = \frac{\text{CI}}{\text{RI}} \quad (5)$$

Information:

λ maks : Value of Eigen Value Maximum

n : number of criteria

While the Random Consistency Index (RI) value is also based on the consistency ratio value table below:

Table 4. Random Consistency Index (RI)

n	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
RI	0,00	0,00	0,58	0,90	1,12	1,24	1,32	1,41	1,45	1,49

Source: Sumarmi, (2019).

Based on the calculation steps above, the calculations have been carried out according to these steps and obtained the weight value and eigenvalue value maximum for each of the criteria as in the table below:

Table 5. Eigen Value

	B	W	KP	KB	P	UT	OC	WSV	Weight	Consistency Vector
B	0,267	0,199	0,413	0,420	0,187	0,355	0,266	2,107	0,267	7,885
W	0,267	0,199	0,248	0,240	0,187	0,284	0,133	1,558	0,199	7,826
KP	0,053	0,066	0,083	0,060	0,187	0,024	0,133	0,606	0,083	7,335
KB	0,038	0,050	0,083	0,060	0,037	0,142	0,066	0,477	0,060	7,947
P	0,267	0,199	0,083	0,300	0,187	0,284	0,133	1,453	0,187	7,768
UT	0,053	0,050	0,248	0,030	0,047	0,071	0,066	0,565	0,071	7,956
OC	0,134	0,199	0,083	0,120	0,187	0,142	0,133	0,997	0,133	7,505
Average										7,746

Source: Data processed

On the results in the table 5, it can be seen that the maximum eigenvalue is 7,746 which is from the calculation of vector consistency. The next step is to calculate the consistency value of the weighting results. Where the standard value is CR ≤ 0.1 (10%) which can be said to be consistent or accepted and otherwise [22]. After the weight value is said to be consistent, it will be continued for AHP weighting for sub criteria or level 2 weighting on KPIs. The weighting results can be seen in the table below:

Table 6. Weight of Analitical Hierarchy Process (AHP)

No	Criteria	Weight Lv 1	Indicator KPI	Weight Lv 2	Global Weight
1	Cost	0,267	Delivery cost	0,532	0,142
			Labor cost	0,118	0,032
			Warehouse rental cost	0,254	0,068
			Stockholder cost	0,096	0,026
2	Time	0,199	Lead time of fertilizer inventory	1	0,199
3	Capacity	0,083	Storage warehouse capacity	1	0,083
4	Capability	0,060	Vendor reliability	0,250	0,015
			Transportation optimization	0,750	0,045
5	Productivity	0,187	Loading unloading workers	1	0,187
6	Utility	0,071	Loading unloading working hours	1	0,071
7	Outcome	0,133	Sharing space	0,250	0,033
			New warehouse	0,750	0,100

Source: Data processed

Based on table 6, the weight value for level 1 and level 2 weight is obtained. Therefore, the results of the global weight or total weight on each KPI indicator are obtained. Nindian and Ismail [23] argue that AHP weighting allows criteria to have the same importance.

3.2. Normalization of Snorm De Boer

The normalization process is used to equalize the actual value scale on each of the company outbound logistics performance indicators. Therefore, the value in the performance results will have the same value scale. The following are the results of snorm de boer normalization:

Table 7. Normalization of Snorm De Boer

No	Indicator KPI	*Snorm*
1.	Delivery cost	96%
2.	Labor cost	85%
3.	Warehouse rental cost	89%
4.	Stockholder cost	86%
5.	Lead time of fertilizer inventory	80%
6.	Storage warehouse capacity	94%
7.	Vendor reliability	90%
8.	Transportation optimization	100%
9.	Loading unloading workers	76%
10.	Loading unloading working hours	80%
11.	Sharing space	100%
12.	New warehouse	86%

Source: Data processed

Based on the table above, it is known that performance measurement can be carried out on KPI indicators that have been validated by Company experts by determining the Company's actual data [24].

3.3. Performance Measurement of Outbound Logistics Result

At this stage, the final calculation of the results of measuring outbound logistics performance in fertilizer distribution activities is carried out. The following are the final results of outbound logistics performance at PT XYZ.

Table 8. Outbound Logistics Performance Measurement Results

No	Criteria	Weight Lv 1	Indicator KPI	Weight Lv 2	Global Weight	*Snorm*	Performance Measurement
1	Cost	0,267	Delivery cost	0,532	0,142	96	13,656
			Labor cost	0,118	0,032	85	2,678
			Warehouse rental cost	0,254	0,068	89	6,033
			Stockholder cost	0,096	0,026	86	2,214
2	Time	0,199	Lead time of fertilizer inventory	1	0,199	80	15,930
3	Capacity	0,083	Storage warehouse capacity	1	0,083	94	7,767
4	Capability	0,060	Vendor reliability	0,250	0,015	90	1,349
			Transportation optimization	0,750	0,045	100	4,497
5	Productivity	0,187	Loading unloading workers	1	0,187	76	14,216
6	Utility	0,071	Loading unloading working hours	1	0,071	80	5,685
7	Outcome	0,133	Sharing space	0,250	0,033	100	3,223
			New warehouse	0,750	0,100	86	8,571
Total Performance							85,918

Source: Data processed

Based on the table above, there are 3 indicators that are not optimal, namely fertilizer inventory lead time with a value of 80, loading and unloading labor with a snorm result of 76 and working hours with a value of 80. And the total performance of the Company's outbound logistics activities as a whole is 85,918 which is included in the good category. Thus, with performance measurement, it can be seen the difference in measured results [25].

3.4. Discussion

In this reseacrh, the results in table 8 it shows that the final total performance based on the POA model and AHP method on PT XYZ's outbound logistics activities is 85,918 which is included in the good category. POA criteria include cost, time, capacity, capability, productivity, utility, and outcome. Of the 12 KPI indicators, there are 3 indicators that have not optimal performance values. In the time criteria, there is an indicator of fertilizer inventory lead time with a performance value of 80 which is not optimal. In the time criteria, there is a lead time indicator for fertilizer supplies with a performance value of 80 which is not optimal. In the productivity criteria there is an indicator of loading and unloading labor with a performance value of 76 and can be said to be not optimal, and in the utility criteria there is an indicator of working hours with a performance value of 80 which is not optimal. Where it can be said that these 3 indicators can be improved with the proposed improvements.

The recommendation for improvement in the time criterion is to make a schedule for planning the distribution of shipments according to the region by providing an early information reminder to the factory. This can be added by checking the screen time of the distribution conditions. In the productivity criteria, the proposed improvement is to conduct written scheduling regarding the activities and the amount of labor needed during operational activities, and in the utility criteria, the proposed improvement is to take attendance and make a schedule of operational activities to be carried out every day to prevent 2 types of work being carried out at the same time.

4. Conclusion

Based on the results of the research, it can be concluded that the total performance value of outbound logistics of PT XYZ's fertilizer distribution activities is 85,918 which is included in the good category. This research uses 12 KPI indicators and there are 3 indicators that have a performance value that is not optimal or < 85, including fertilizer inventory lead time with a performance value of 80, loading and unloading labor of 76, and working hours with a performance value of 80. These three indicators can be improved by proposing improvements, namely planning and scheduling operational activities for the company's outbound logistics activities. This research does not use production time flexibility indicators, because this research focuses on the outbound logistics performance of finished products. So, future research can add production time flexibility to the KPI in order to obtain more detailed outbound logistics performance results and further research can be carried out with the collaboration of the AHP method and other methods such as the SCOR method to facilitate the selection of SCM process activities or using the Fuzzy AHP method to reduce research subjectivity.

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