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Applying Mathematical Model to Determine Location Facilities Storage Optimally With Integrated Logistic System Of Supply Chain For The Industrial Area of The People

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ABSTRACT

High logistics costs of Indonesia led to lower competitiveness of production Indonesia. To overcome this problem needs to be done implementation of logistics integrated and supply chain of input-output system of production of the company's in the industrial area of the people. The application can occur with integration of communication systems, transportation systems, facilities systems, and the provision of resources system, as well as warehousing systems, the management coordination and operation of logistics integrated and supply chain can be obtained effectiveness and efficiency, economy and productivity together. One of the important, how to determine for warehouse a company on the industrial area of the people. His problem there are several warehouses can be selected for logistics costs low. Way of solving this problem with the research application of mathematical models to calculate the most optimal warehouse from several warehouses that can be used. Mathematical model to be applied in the model matrix equation. From the data obtained three equations warehouse, and the warehouse where the most optimal of the third warehouse to warehouse production of a company then obtained matrix model is a model matrix of order three. With the completion of the matrix obtained value most optimal warehouse costs. The mathematical model can also be applied to determine the production warehouse of several other companies in the area of the Indonesia industry. This research was also useful for the development of green economy on land and at sea, with the approach of the industrial area of the people. If mathematical models applied to integrated logistics systems and supply chains on the industrial area of the people. then obtained a low cost logistics. Thereby increasing the competitiveness of the green economy on people's industrial area

Keywords: *Management Logistics Integrated And Supply Chain, Applying Mathematical Model to Warehouse Selection.*

INTRODUCTION

ASEAN free trade implementation will begin immediately, will have an impact on the improvement of the competitiveness of production the peoples. How to about the competitiveness of production of the Indonesian people are still far from satisfactory, the competitiveness of Indonesia's production is still low, due to the high cost of logistics (approximately 40%). Indonesia's logistics performance is very low compared to other countries, to solve this problem Indonesia need to implement an integrated logistics management and supply chain in the industrial area of the people, so that the region can be applied to input-output system of production factors and production with supply chain management. As well as integrated communication systems, transportation systems, facilities systems, and the provision of system resources, as well as warehousing system. With the coordination and management of logistics operations will be obtained optimal. effectiveness, efficiency, economy, productivity (3EP). One program that strongly supports the implementation of a warehouse is to determine some of the existing warehouse to a company's most optimal. Study the application of mathematical models greatly help solve this problem.

This research used qualitative and quantitative data. Qualitative data is used for non-statistical analysis. Meanwhile, quantitative data is used for statistical analysis. It also has primary and secondary data. The primary data is obtained directly from logistics manageress and the secondary data is obtained from other parties related to the research.

The measurement of the answer is based on Analytical Hierarchy Process method (AHP). (Marimin dan Nurul Maghfiroh, 2010) Analytical Hierarchy Process (AHP) is a systematic decision making method which was introduced by Thomas L. Saaty during 1971 - 1975 when he was in Wharton School. It is used if there are various criteria of the decision making. There are some principals that need to be understood from the AHP method, namely: decomposition, comperative judgment, synthesis of priority, and logical consistency. Furthermore, AHP also has a special concern about the deviations of consistency in the pairwise comparison matrix. First, the decision makers make a scoring on the relative importance between two elements qualitatively of "vertical (ci)" element with "horizontal (cj)" element in the pairwise comparison matrix using the following

formula. Formulation based on kreteria of several warehouse A, B and C, that are related to system capacity warehousing, warehousing facilities systems, transportation system, costs of logistics warehousing, all on the industrial area of the people. Pay attention to the formulation of a mathematical model to solve the problems here.

Some kreteria for consideration in the selection of a storage area from several companies in the industrial area of:

a. Warehouse's width; this is the first criteria should be considered.
b. Facilities; assessed only on the availability of pallets owned by the suppliers and types of storage facilities on each alternative which are racking and stacking blocks (bulk)
c. cost; assessed from the rental and shipping costs from the factory to the warehouse as well as the cost per pallet.
d. Location; assessed from the distance and travel time between factories and warehouses

What being analyzed in this case is three warehouses on the industrial area of the people. With their own criteria, namely warehouse A, B, and C.
Table. 2. is pairwise comparison matrix of the criteria of warehouse selection equiped with the relative importance score between elements and values of axioms Reciprocal based on the results of relative importance score between elements of decision makers value.

The table is the initial assessment done by comparing the vertical elements with horizontal elements.

a. Warehouse's width is more important than facilities so it is weighted 3.
b. Cost is more important than warehouse's width so it is weighted 3.
c. Warehouse's width is more important than location so it is weighted 5.
d. Cost is more important than facilities so it is weighted 5.
e. Facilities is more important than location so it is weighted 3.
f. Cost is more important than location so it is weighted 5.

The matrix gave result to the total value for each column that is Eigen value (Z) of the pairwise comparison matrix. Column that has the smallest Eigen value will be the highest priority score to the normalized matrix. Table. 3. refers to normalized matrix which was gained from the division of the pairwise comparison matrix and the Eigen value of each column. It shows the results of the perfect normalization calculations, as the total value of each column is 1.0000, as well as the priority scores for each criterion. After getting the priority score, the next is to test the consistency of the results of relative importance score between elements by setting the value of Consistency Ratio (CR) through the following steps:

A. Counting the Eigen Vector Score.

$AW = Z_{maka} * w$

$$AW0 = \begin{pmatrix} 1,0000 & 3,0000 & 0,3333 & 5,0000 \\ 0,3333 & 1,0000 & 0,2000 & 3,0000 \\ 5,0000 & 1,0000 & 5,0000 & \\ 0,2000 & 0,3333 & 0,2000 & 1,0000 \end{pmatrix} \begin{pmatrix} 0,2729 \\ 0,1276 \\ 0,5329 \\ 0,0667 \end{pmatrix} = \begin{pmatrix} 1,1666 \\ 0,5251 \\ 2,3227 \\ 0,2703 \end{pmatrix}$$

Z_{makx} = 1,1666 + 0,5251 + 2,3227 + 0,2703
= 4,2847

The Eigen values (Zmax) is 4.2847
It shows that each element (criterion) contains the priority score of the element.

B. Counting the Consistency Index (CI).

$$CI = \frac{Z_{makx} - n}{n - 1} = \frac{4,2847 - 4}{4 - 1}$$

C. Counting the Consistency Ratio (CR).

$$CR = \frac{CL}{RI} = \frac{0,0949}{0,90} = 0,1055$$

n is criteria compared. Based on table 1 RI score for n = 4 is 0.90
The CR value gained from the calculation above is 0.1055. Because CR < 0.10 then, there is no need to do the assessment revision because the priority score of each alternative is consistent and valid

Priority decision against kreteria system capacity warehousing

The first criterion is to perform pairwise comparisons for each alternative of warehouse's width criterion. Filling the relative importance score of each alternative against the warehouse's width criterion is done by using the result of the interviews done to the logistics managers, as seen on table. 4.
The table is the initial assessment done by comparing the vertical elements with horizontal elements.

a. Alternative Warehouse B is more important than alternative Warehouse A, so it is weighted 3.
b. Alternative Warehouse C is much more important than alternative Warehouse A so it is weighted 7.
c. Alternative Warehouse C is more important than alternative Warehouse B so it is weighted 5.
The matrix gave result to the total value for each column that is Eigen value (Z) of the pairwise comparison matrix of the warehouse's width. Next is to make the normalized matrix as shown in table. 5. Table. 5. refers to normalized matrix which was gained from the division of the pairwise comparison matrix of warehouse's width criterion and the Eigen value of each column. It shows the results of the perfect normalization calculations, as the total value of each column is 1.0000. It also shows the priority scores for each column. After getting the priority score, the next is to test the consistency of the relative importance assessment between elements by setting. The value of Consistency Ratio (CR) through the following steps:

a. Counting the Eigen vector

$$AW = Z_{maks} \cdot w$$

$$Aw = \begin{pmatrix} 1,0000 & 0,3333 & 0,1429 \\ 3,0000 & 1,0000 & 0,2000 \\ 7,0000 & 5,0000 & 1,0000 \end{pmatrix} \begin{pmatrix} 0,0833 \\ 0,1932 \\ 0,7235 \end{pmatrix}$$

$$= \begin{pmatrix} 1,0000 \\ 3,0000 \\ 7,0000 \end{pmatrix}$$

$$Z_{maks} = 0,2511 + 0,5878 + 2,2726$$
$$= 3,1115$$

The Eigen values (Zmax) is 3.1115. It shows that each element (criterion) contains the priority score of the element.

b. Counting the Consistency Index (CI).

$$CI = \frac{Z_{maks} - n}{n - 1} = \frac{3,1115 - 3}{3 - 1} = 0,0557$$

c. Counting the Consistency Ratio (CR).

$$CR = \frac{CL}{RI} = \frac{0,0557}{0,58} = 0,0961$$

n is criteria compared. Based on table 1 RI score for n = 3 is 0.58The CR value gained from the calculation above is 0.0961. Because CR < 0.10 then, there is no need to do the assessment revi sion because the priority score of each alternative is consistent and valid.

Compare each system facilities owned warehouse in the warehouse selection

The next process is to perform pairwise comparisons for each alternative against the facilities criterion. Filling the relative importance score of each alternative against the facilities criterion is done by using the* result of the interviews done to the logistics managers like the steps taken before as shown in the matrix of table 6. The matrix gave result to the total value for each column that is Eigen value (Z) of the pairwise comparison matrix of

the facilities. Next is to make the normalized matrix as shown in table. 7. Table. 7. refers to normalized matrix which was gained from the division of the pair-wise comparison matrix of facilities criterion and the Eigen value of each column. It shows the results of the perfect normalization calculations, as the total value of each column is 1 .0000. It also shows the priority scores for each column. After getting the priority score, the next is to test the consistency of the relative importance assessment between elements by setting the value of Consistency Ratio (CR) through the following steps:

a. Counting the Eigen vector

$AW = Z_{maka}\text{-}w$

$$Aw = \begin{bmatrix} 1,0000 & 2,0000 & 2,0000 \\ 0,5000 & 1,0000 & 2,0000 \\ 0,5000 & 0,5000 & 1,0000 \end{bmatrix} \begin{bmatrix} 0,4905 \\ 0,3119 \\ 0,1976 \end{bmatrix}$$

$$= \begin{bmatrix} 1,5095 \\ 0,9524 \\ 0,5988 \end{bmatrix}$$

Z_{makx} = 1,5095 + 0,9524 + 0,5988
= 3,0607

The Eigen values (Zmax) result is 3.0607. It shows that each element (alternative) contains the priority score of the element.

b. Counting the Consistency Index (CI).

$$CI = \frac{Z_{makx} - n}{n - 1} = \frac{3,0607 - 3}{3 - 1} = 0,0304$$

c. Counting the Consistency Ratio (CR).

$$CR = \frac{CI}{RI} = \frac{0,0304}{0,58} = 0,0523$$

Based on the above calculation, the CR value is 0.0523. Because CR < 0.10 then, there is no need to do the assessment revision because the priority score of each alternative is consistent and valid.

Comparing the warehouse selection based on logistic cost kreteria

The next process is to perform pairwise comparisons for each alternative against the criteria of cost. Filling the relative importance score of each alternative against the Cost criterion is done by using the result of the interviews done to the logistics managers and resulted in the matrix of table. 8. The matrix gave result to the total value for each column that is Eigen value (Z) of the pairwise comparison matrix of the cost. Next is to make the normalized matrix as shown in table. 9. Table. 9. refers to normalized matrix which was gained from the division of the pair-wise comparison matrix of cost criterion and the Eigen value of each alternative. After getting the priority score, the next is to test the consistency of the relative importance assessment between elements by setting the value of Consistency Ratio (CR) through the following steps:

a. Counting the Eigen vector

$AW = Z_{maka}\text{-}w$

$$Aw = \begin{bmatrix} 1,0000 & 5,0000 & 0,3333 \\ 0,2000 & 1,0000 & 0,1429 \\ 3,0000 & 7,0000 & 1,0000 \end{bmatrix} \begin{bmatrix} 0,2828 \\ 0,0738 \\ 0,6435 \end{bmatrix}$$

$$= \begin{bmatrix} 0,8662 \\ 0,2223 \\ 2,0083 \end{bmatrix}$$

Z_{makx} = 0,8662 + 0,2223 + 2,0083 = 3.0967

The Eigen values (Z max) result is 3.0967. It shows that each element (alternative) contains the priority score of the element

b. Counting the Consistency Index (CI).

$$CI = \frac{Z_{makx} - n}{n - 1} = \frac{3{,}0967 - 3}{3 - 1} = 0{,}0484$$

c. Counting the Consistency Ratio (CR).

$$CR = \frac{CI}{RI} = \frac{0{,}0484}{0{,}58} = 0{,}0834$$

Based on the above calculation, the CR value is 0.0834. Because CR < 0.10 then, there is no need to do the assessment revision because the priority score of each alternative is consistent and valid.

Comparing transportation system on alternativ location the warehouse selected

Then, the process followed by pairwise comparisons for each alternative against the criterion of location using the result of the interviews to the logistics managers so we get a pairwise comparison matrix as seen on table. 10. The matrix gave result to the total value for each column that is Eigen value (Z) of the pairwise comparison matrix of the location. Next is to make the normalized matrix as shown in table .11. Table. 11. refers to normalized matrix which was gained from the division of the pairwise comparison matrix of location criterion and the Eigen value of each column. It shows the results of the perfect normalization calculations, as the total value of each column is 1.0000. It also shows the priority scores for each column. After getting the priority score, the next is to test the consistency of the relative importance assessment between elements by setting the value of Consistency Ratio (CR) through the following steps:

a. Counting the Eigen vector

$AW = Z_{maka}\text{-}w$

$$Aw = \begin{bmatrix} 1{,}0000 & 5{,}0000 & 3{,}0000 \\ 0{,}2000 & 1{,}0000 & 0{,}3333 \\ 0{,}3333 & 3{,}0000 & 1{,}0000 \end{bmatrix} \begin{bmatrix} 0{,}6333 \\ 0{,}1062 \\ 0{,}2605 \end{bmatrix} \begin{bmatrix} 1{,}9456 \\ 0{,}3197 \\ 0{,}7901 \end{bmatrix}$$

$Z_{makx} = 1{,}9456 + 0{,}3197 + 0{,}7901$

$= 3{,}0554$

The Eigen values (Zmax) result is 3.0554. It shows that each element (alternative) contains the priority score of the element

b. Counting the Consistency Index (CI).

$$CI = \frac{Z_{makx} - n}{n - 1} = \frac{3{,}0554 - 3}{3 - 1} = 0{,}0277$$

c. Counting the Consistency Ratio (CR).

$$CR = \frac{CI}{RI} = \frac{0{,}0277}{0{,}58} = 0{,}0477$$

Based on the above calculation, the CR value is 0.0477. Because CR < 0.10 then,
there is no need to do the assessment revision.

Decision making on selection of warehouse company with the highest score in the industrial area of the people

The last process in the calculation of Analytical Hierarchy Process (AHP) is to calculate the aggregate score of each alternative warehouse which was obtained by multiplying the priority score of each alternative on all criteria with a priority score of each criterion. The alternative warehouse that has the highest aggregate value is chosen as a reference in decision-making. Table.12. shows the aggregate scoring.

Table.12. Results Final Scoring of Each Alternative

	Warehouse's width	Facilities	Cost	Location	Aggregate Value
	0.2729	**0.1276**	**0.5329**	**0.0667**	
Warehouse A	**0.0833**	**0-4905**	**0.2828**	**0.6333**	**0.2783**
Warehouse B	**0..1932**	**0.3119**	**0.0738**	**0.1062**	**0.1389**
Warehouse C	**0.7235**	**0.1976**	**0.6434**	**0.2605**	**0.5829**

CONCLUSION

Mathematics models has been able to answer how to determine the optimal warehouse of a company located in the industrial area of the people. Have a choice of three warehouses. On the industrial area of the people. The selection depends on the kreteria capacity of the warehouse shed, warehouse facilities, systems transportation. Use the system of logistics integrated and supply chain. retrieved the system inputs and outputs. From the input data obtained incorporated into the formulation of the three last-order matrix equation solved math, the obtained results that matter optimal warehouse C more than the A and B warehouse for the company. Table.12. Likewise, if we want to find a suitable warehouse for other companies with do the same mathematical model. So the conclusion has been reached and the purpose of this study to determine the appropriate of warehouse, a company located in the industrial area of the people, with management logistics integrated and supply chain. Warehouse C was selected the storage company's in the industrial of the people, as it has aggegate score high, one and half hour to get there. The cost that needs to be prepared by the company is Rp 1,413.036,625 as the delivery cost from the factory to the warehouse is Rp 1,300,000 and the cost per pallet is Rp 31,625.

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Lampiran

Tabel. I Random Index (RI) Score

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

Source: Sri Mulyono (2001)

Table *2* Pairwise Comparison Matrix of Warehouse Selection Criteria

Focus	Ware-house's width		Facili-ties		Cost		Loca-tion	
		4 digit decimal		4 digit decimal		4 digit decimal		4 digit decimal
Warehouse's width	1	1.0000	3	3.0000	1/3	0.3333	5	5.0000
Facilities	1/3'	0.3333	1	1.0000	1/5	0.2000	3	3.0000
Cost	3*	3.0000	5*	5.0000	1	1.0000	5	5.0000
Location	1/5*	0,2000	1/3*	0.3333	1/5*	0,2000	\	1.0000
Total		4.5333		9.3333		1.7333		14.000

Source: Processed interview result
* = reverse score (axioms reciprocal)

Table 3 Normalized Matrix

Focus	**Warehouse's width**	**Facilities**	**Cost**	**Location**	**Priority Score**
Warehouse's width	0.2206	0.3214	0.1923	0.3571	0.2729
Facilities	0.0735	0.1072	0.1154	0.2144	0.1276
Cost	0.6618	0.5357	0.5769	0.3571	0.5329
Location	0.0441	0.0357	0.1154	0.0714	0.0666
Total	1 .0000	1 .0000	1.0000	1.0000	1.0000

Source: Processed Interview result

Table 10 Location Pairwise Comparison Matrix

Warehouse's »idth criterion		Warehouse A		Warehouse B		Warehouse C
		4 digit decimal		4 digit decimal		4 digit decimal
Warehouse A	1	1.0000	5	5.0000	3	3.0000
Warehouse B	1/5*	0.2000	1	1 .0000	1/3	0.3333
Warehouse C	1/3*	0.3333	3*	3.0000	1	LOOOO
Total		1.5333		9.0000		4.3333

Source: Processed Interview result
* = reverse score (axioms reciprocal)

Table 11 Normalized Matrix

Location Criterion	Warehouse A	Warehouse B	Warehouse C	Priority Score
Warehouse A	0.6522	0.5556	0.6923	0.6333
Warehouse B	0.1304	0-1111	0.0769	0.1062
Warehouse C	0.2174	0.3333	0.2308	0.2605
Total	1 .0000	1 .0000	1-0000	1 .0000

Source: Processed Interview result

Table 12 Final Scoring of Each Alternative

	Warehouse's width	Facilities	Cost	Location	Aggregate Value
	0.2729	0.1276	0.5329	0.0667	
Warehouse A	0.0833	0-4905	0.2828	0.6333	0.2783
Warehouse B	0..1932	0.3119	0.0738	0.1062	0.1389
Warehouse C	0.7235	0.1976	0.6434	0.2605	0.5829

Data source: processed by the writer