

Analysis of Multi Criteria Classification and Inventory Planning on Flexible Packaging Industry

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Abstract

Inventory is identical to goods or items stored in a place that will be used at a certain time and purpose. In a manufacturing industry, the availability of raw materials is very important for the continuity of the production process. In the manufacturing industry, the role of packaging is very important. In Indonesia itself, the types of packaging that are circulating in terms of material consist of flexible packaging, rigid packaging, paperboard, and other types of packaging. Based on Ministry of Industry, flexible packaging is the most used packaging in Indonesia. Inventory are called efficient and effective if the supply can meet demand in sufficient quantities and adequate quality, because accuracy in fulfilling a need's supply will have an impact on efficiency in a company in meeting customer needs. But sometimes, the number of types of inventories stored in the warehouse is sometimes difficult to control, so a reference is needed to prioritize which inventory needs to be given more attention, for that we need a method to determine which inventory items should be analyzed more specifically. To control the inventory, we should see from many criteria, so this research aims to use multi criteria decision making to rank and prioritize the type of Inventory in Flexible Packaging Industry.

Keywords

Multi criteria, Fuzzy AHP and Flexible Packaging.

1. Introduction

Inventory is synonymous with goods or items stored in a place that will be used at a certain time and purpose. For example, inventory of raw materials stored in a raw material warehouse will be used or transformed into finished goods to be sold to customers through the production process. Inventory consists of several types, including raw material inventory, finished goods inventory and so on. In a manufacturing industry, the availability of raw materials is very important for the continuity of the production process. The function of inventory, among others, is to expedite the production process in production planning, anticipate material shortages and price increases, reduce dependency between items, and assist in getting price discounts on purchases. (Gupta and Star 2014).

In the manufacturing industry, the role of packaging is very important because every product requires packaging to be sent to customers. In Indonesia, the types of packaging that are circulating in terms of material consist of flexible packaging, rigid packaging, paperboard, and other types of packaging. Based on its use, the type of flexible packaging that is circulating and used the most in Indonesia is 44%, followed by paperboard packaging at 28% which can be seen in Figure 1.

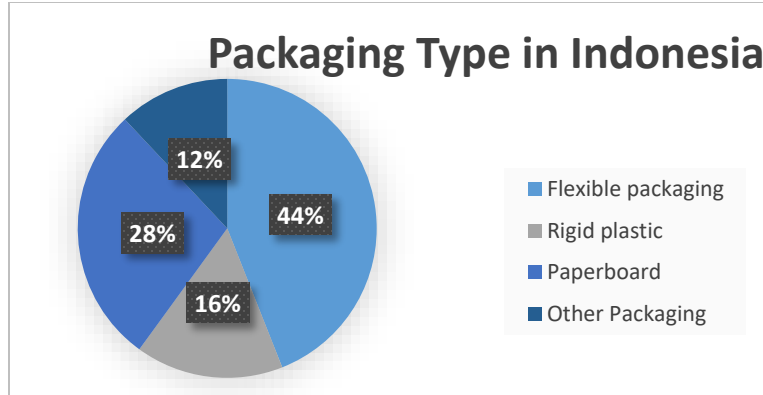


Figure 1. Packaging Type in Indonesia
(Source: Kemenperin.go.id)

The flexible packaging type of packaging industry occupies the largest position compared to other types of packaging circulating in Indonesia, so that indirectly the existence of flexible packaging that matches market demand will expedite the supply chain of other industries. Therefore, the availability of flexible packaging is very reliable. So that the availability of flexible packaging is always available, it is necessary to have supportive inventory management.

Inventory will be efficient and effective if supply can meet demand in sufficient quantities and adequate quality because accuracy in fulfilling a need's supply will have an impact on efficiency within a company in meeting customer needs (Wulansari 2017). In fulfilling inventory, a company or organization must replenish goods or items when they reach the reorder point. Each company or organization applies a different system or approach in determining the analysis of the time and amount of stock replenishment. The approaches used include continuous review and periodic review. The continuous review approach is carried out by continuously monitoring the amount of stock in the storage warehouse, then replenishing or reordering when an item is at a certain point, while the periodic review approach is carried out by analyzing and replenishing inventory at specified time intervals. (Slack 2013).

In determining the number of items that must be replenished, the periodic review approach must be carried out carefully, because it can cause a shortage if the supply is insufficient before the replenishment period. However, on the other hand, companies cannot simply place orders in large quantities because it will cause overstock and can disrupt the company's financial cash flow.

The large number of types of inventories stored in storage warehouses is sometimes difficult to control, so a reference is needed to prioritize which inventory needs more attention, for this reason a method is needed to determine which inventory items must be prioritized more specifically compared to other inventory items. However, to choose which inventory items to prioritize is sometimes difficult because there are various criteria that can affect the importance of the existence of an inventory. These criteria can be in the form of inventory lead times from when it was first ordered until it arrives, costs spent on buying these supplies, the number of requests for the use of these inventory items or even the useful life or expiration time of these inventory items. Therefore, the existence of a method for selecting the priority of multi-criteria inventory is needed, one of the methods that can be used is the AHP fuzzy method. The main idea of AHP in selecting multi-criteria inventory is to find the weight of inventory items by comparing them in pairs between the criteria that influence them (Nag 2019). The weighting is carried out or assessed by experts in the field concerned by giving a score to each of the alternatives provided. One of the drawbacks of AHP itself is the assessment which tends to be subjective. Therefore, to overcome these weaknesses, an advanced method was developed in the form of fuzzy AHP. Fuzzy AHP is a method that combines AHP with fuzzy set theory.

After knowing what inventory items need to be prioritized with other inventory items, it is necessary to analyze how much and the time period for replenishment or replenishment of inventory. However, the amount of usage or demand for supplies sometimes cannot be known with certainty so that supplies often run out when they want to be

needed, which can reduce production effectiveness which can result in reduced production yields and potentially lower sales. To predict the demand or use of a supply, the monte carlo simulation method can be used as an illustration and consideration in determining the optimum order quantity and reorder point time (ROP).

2. Methods

The methodology in this study can be follow on this step:

1. Collecting data
The data collected at the AHP fuzzy stage is in the form of a hierarchical structure and filling out a pairwise comparison questionnaire between variables with the Saaty ratio scale.
2. Calculating Priority Weight
Calculation of priority weights is obtained from the results of the eigenvectors divided by the total eigenvectors. The results of this priority weight calculation will be multiplied by the paired matrix to become the priority weight vector.
3. Calculating the value of λ_{max}
The calculation of the λ_{max} value will be useful in CI and CR calculations. The value of λ_{max} is obtained from the average priority weight vector.
4. Calculating CI and CR values
CI and CR values are used to determine consistency in filling out pairwise comparisons. If $CR \leq 10\%$ then the pairwise comparison matrix is said to be consistent, meaning that the relationship between the criteria justifies each other logically.
5. TFN transformation
TFN transformation is changing the value of the Saaty AHP scale into a triangular fuzzy number (TFN) with predetermined conditions.
6. Calculation of Fuzzy Synthetic Extents
Fuzzy synthetic extent functions to change non-fuzzy inputs to fuzzy sets using fuzzification rules.
7. Comparison between Fuzzy Synthetic Extent values
This comparison of the level of possibility is used for the weight value on each criterion which will become the weight vector value.
8. Normalization
The results of the normalization of the weight vector are the results of the weights or ratings of the problems studied.

3. Data Collection

In this study, researchers collected data from various sources, namely from conducting literature studies and interviews with sources who are experts in their fields to determine the classification in the hierarchical structure which will be processed using fuzzy AHP, then a weight comparison questionnaire will be distributed back to the resource persons to be assessed. The following is the data collected for this study:

1. Hierarchy Structure

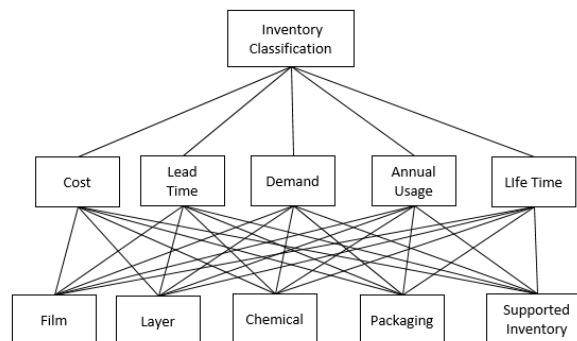


Figure 2. Hierarchy Structure

2. Comparison Test Between Criteria

Determination of weight is done by pairwise comparison test between criteria. Where the criteria used in this study can be seen through a hierarchical structure, namely in the form of cost, lead time, demand, annual usage and Life time. The pairwise comparison test was carried out by filling out a questionnaire of 3 respondents who were experts in their fields. In filling out the comparative test questionnaire, the scale used is the Saaty measurement scale (scale 1 to 9). The following Tables 1-6 are the results of the pairwise comparison test between criteria:

Table 1. Questionnaire Results Paired Comparison of Criteria Respondent 1

Criteria	Cost	Lead Time	Demand	Annual Usage	Life Time
Cost	1	5	3	5	7
Lead Time		1	3	3	3
Demand			1	9	5
Annual Usage				1	5
Life Time					1

Table 2. Questionnaire Results Paired Comparison of Criteria Respondent 2

Criteria	Cost	Lead Time	Demand	Annual Usage	Life Time
Cost	1	5	3	5	7
Lead Time		1	3	5	7
Demand			1	9	7
Annual Usage				1	5
Life Time					1

Table 3. Questionnaire Results Paired Comparison of Criteria Respondent 3

Criteria	Cost	Lead Time	Demand	Annual Usage	Life Time
Cost	1	5	9	5	7
Lead Time		1	3	5	7
Demand			1	9	5
Annual Usage				1	5
Life Time					1

3. Comparison Test between Alternative

The pairwise comparison test was carried out by filling out a questionnaire by 3 respondents who are experts in their field where the variables tested in pairs between these alternatives are types of inventory that can be seen in the previous hierarchical structure. The scale used is the Saaty measurement scale (scale 1 to 9). The following is the result of the pairwise comparison test between the three alternative respondents:

Table 4. Questionnaire Results Paired Comparison of Alternative Respondent 1

Alternative	Film	Layer	Chemical	Packaging	Supported Inv
Film	1	7	5	9	9
Layer		1	5	7	9
Chemical			1	3	5
Packaging				1	5
Supported Inv					1

Table 5. Questionnaire Results Paired Comparison of Alternative Respondent 2

Alternative	Film	Layer	Chemical	Packaging	Supported Inv
Film	1	3	7	7	9
Layer		1	5	5	7
Chemical			1	8	5

Packaging		1	5
Supported Inv			1

Table 6. Questionnaire Results Paired Comparison of Alternative Respondent 3

Alternative	Film	Layer	Chemical	Packaging	Supported Inv
Film	1	5	5	7	9
Layer		1	5	7	7
Chemical			1	7	5
Packaging				1	5
Supported Inv					1

4. Results and Discussion

1. Criteria Consistency Ratio

- The first step is to create a paired matrix between the criteria for each respondent.

Table 7. Matrix Comparison of Criteria

Criteria	Responden 1					Responden 2					Responden 3				
	C	LT	D	A	L	C	LT	D	A	L	C	LT	D	A	L
C	1	5	3	5	7	1	5	3	5	7	1	1/5	1/9	5	7
LT	1/5	1	1/3	3	3	1/5	1	1/3	5	7	5	1	1/3	5	7
D	1/3	3	1	9	5	1/3	3	1	9	7	9	3	1	9	5
A	1/5	1/3	1/9	1	1/5	1/5	1/5	1/9	1	1/5	1/5	1/5	1/9	1	1/5
L	1/7	1/3	1/5	5	1	1/7	1/7	1/7	5	1	1/7	1/7	1/5	5	1

- Next, the geometric mean, eigen vector and priority weights are calculated. The geometric mean is performed if the respondent gives an assessment > 1. The following is the calculation of the geometric mean criteria:

Table 8. Geometric mean, eigen vector, priority weight

Criteria	Geometric Mean					Eigen Vector	Priority Weight
	C	LT	D	A	L		
C	1	1,710	1	5	7	2,267	0,322
LT	0,585	1	0,333	4,217	5,278	1,341	0,190
D	1	3	1	9	5,593	2,278	0,387
A	0,2	0,237	0,111	1	0,2	0,254	0,036
L	0,143	0,189	0,147	5	1	0,457	0,065

- Next step, the geometric mean value is multiplied by the priority weight vector to produce a total weight vector.
- the value of the total weight vector is divided by the priority weight and the result is expressed as the priority vector.
- Then the average value of the priority vector is calculated so that the result is called λ_{maks} .
- The Consistency Index (CI) value is calculated using the following formula :

$$\begin{aligned}
 CI &= \frac{\lambda_{maks} - n}{n-1} \\
 &= \frac{5,408-5}{4} \\
 &= 0,102
 \end{aligned}$$

- Calculate the consistency ratio n = 5 and RI = 1,12. The Consistency Ratio (CR) value is calculated using the following formula:

$$\begin{aligned}
 CR &= \frac{CI}{RI} \\
 &= \frac{0,102}{1,12}
 \end{aligned}$$

= 0,091

Because the CR value $\leq 10\%$, it can be said that the matrix comparison for the criteria are consistent, so it can be continued for further calculations.

2. Weighting Criteria with Fuzzy AHP

- Convert the pairwise comparison into TFN numbers (Triangular Fuzzy Number).
- After the pairwise comparison values of all respondents were converted into TFN values, all data were then combined and averaged to obtain a combined fuzzification for the criteria as follows:

Table 9. Combined Fuzzification

Criteria	C	LT	D	A	L
C	(1,1,1)	(2.05,3.4,4.78)	(0.7,2.04,3.38)	(3,5,7)	(5,7,9)
LT	(1.1,1.8,2.56)	(1,1,1)	(0.2,0.33,1)	(2.33,4.33,6.33)	(3.67,5.67,7.67)
D	(2.47,3.22,3.67)	(1,3,5)	(1,1,1)	(7,9,9)	(3.67,5.67,7.67)
A	(0.14,0.2,0.33)	(0.16,0.24,0.56)	(0.11,0.11,0.14)	(1,1,1)	(0.14,0.2,0.3)
L	(0.11,0.14,0.2)	(0.14,0.21,0.47)	(0.13,0.18,0.29)	(3,5,7)	(1,1,1)

- Add up each TFN number in each row.
- The next step is to add up all the TFN numbers in the pairwise comparison matrix to get the following results in Table 10:

Table 10. Total TFN Value of Criteria

	l	m	u
	41.123	61.745	81.368

- Next the fuzzy synthetic extent value is calculated for each main criterion as follows in Table 11:

Table 11. Fuzzy Synthetic Extent of Criteria

	l	m	u
S1	0.144	0.299	0.612
S2	0.102	0.213	0.451
S3	0.186	0.355	0.64
S4	0.019	0.028	0.058
S5	0.054	0.106	0.218

- Then do a comparison of the level of possibility between fuzzy synthetic extents with their minimum value

Table 12. Comparison of Fuzzy Synthetic Extent Criteria Values

	S1 \geq	S2 \geq	S3 \geq	S4 \geq	S5 \geq
S1		0.781	1	0	0.276
S2	1		1	0	0.52
S3	0.884	0.652		0	0.113
S4	1	1	1		1
S5	1	1	1	0.045	
min	0.884	0.652	1	0	0.113

- Then calculate the weights and normalize the weight vectors so that the main criteria weight values are known.

Table 13. Normalized Criteria Weight Vector

	W'	W
C	0.884	0.334
LT	0.652	0.246
D	1	0.378
A	0	0
L	0.113	0.043

3. Alternative Consistency Ratio

- The first step is to create a paired matrix between the criteria for each respondent.

Table 14. Matrix Comparison of Alternative

Alternative	Responden 1					Responden 2					Responden 3				
	F	L	C	P	S	F	L	C	P	S	F	L	C	P	S
F	1	1/7	5	9	9	1	3	7	7	9	1	5	5	7	9
L	7	1	5	7	9	1/3	1	5	5	7	1/5	1	5	7	7
C	1/5	1/5	1	3	5	1/7	1/5	1	8	5	1/5	1/5	1	7	5
P	1/9	1/7	1/3	1	1/5	1/6	1/5	1/8	1	5	1/7	1/7	1/7	1	1/5
S	1/9	1/9	1/5	5	1	1/9	1/7	1/5	1/5	1	1/7	1/7	1/5	5	1

- Next, the geometric mean, eigen vector and priority weights are calculated. The geometric mean is performed if the respondent gives an assessment > 1. The following is the calculation of the geometric mean criteria:

Table 15. Geometric mean, eigen vector, priority weight

Alternative	Geometric Mean					Eigen Vektor	Bobot Prioritas
	F	L	C	P	S		
F	1	1.289	5.593	7.612	9	3.457	0.436
L	0.776	1	5	6.257	7.612	2.84	0.358
C	0.179	2	1	5.518	5	0.997	0.126
P	0.131	0.16	0.181	1	0.585	0.295	0.037
S	0.111	0.131	0.2	1.71	1	0.346	0.044

- Next step, the geometric mean value is multiplied by the priority weight vector to produce a total weight vector.
- the value of the total weight vector is divided by the priority weight and the result is expressed as the priority vector.
- Then the average value of the priority vector is calculated so that the result is called λ_{maks} .
- The Consistency Index (CI) value is calculated using the following formula:

$$\begin{aligned}
 CI &= \frac{\lambda_{maks} - n}{n - 1} \\
 &= \frac{5,331 - 5}{4} \\
 &= 0,083
 \end{aligned}$$

- Calculate the consistency ratio $n = 5$ and $RI = 1,12$. The Consistency Ratio (CR) value is calculated using the following formula:

$$\begin{aligned}
 CR &= \frac{CI}{RI} \\
 &= \frac{0,083}{1,12} \\
 &= 0,074
 \end{aligned}$$

Because the CR value $\leq 10\%$, it can be said that the matrix comparison for the criteria is consistent, so it can be continued for further calculations.

4. Weighting Alternative with Fuzzy AHP

- Convert the pairwise comparison into TFN numbers (Triangular Fuzzy Number).
- After the pairwise comparison values of all respondents were converted into TFN values, all data were then combined and averaged to obtain a combined fuzzification for the criteria as follows:

Table 16. Combined Fuzzification

	F	L	C	P	S
F	(1,1,1)	(1/9,1/7,1/5)	(3,5,7)	(7,9,9)	(7,9,9)
L	(5,7,9)	(1,1,1)	(3,5,7)	(5,7,9)	(7,9,9)
C	(1/7,1/5,1/3)	(1/7,1/5,1/3)	(1,1,1)	(1,3,5)	(3,5,7)
P	(1/9,1/9,1/7)	(1/9,1/7,1/5)	(1/5,1/3,1)	(1,1,1)	(1/7,1/5,1/3)
S	(1/9,1/9,1/7)	(1/9,1/9,1/7)	(1/7,1/5,1/3)	(3,5,7)	(1,1,1)

- Add up each TFN number in each row.
- The next step is to add up all the TFN numbers in the pairwise comparison matrix to get the following results:

Table 17. Total TFN Value of Alternative

	l	m	u
	48.641	69.078	86.671

- Next the fuzzy synthetic extent value is calculated for each main criterion as follows:

Table 18. Fuzzy Synthetic Extent of Alternative

	l	m	u
S1	0.216	0.377	0.632
S2	0.182	0.326	0.592
S3	0.095	0.179	0.335
S4	0.028	0.048	0.091
S5	0.039	0.07	0.132

- Then do a comparison of the level of possibility between fuzzy synthetic extents with their minimum value.

Table 19. Comparison of Fuzzy Synthetic Extent Alternative Values

	S1 \geq	S2 \geq	S3 \geq	S4 \geq	S5 \geq
S1		0.880	0.376	0	0
S2	1		0.510	0	0
S3	1	1		0	0
S4	1	1	1		1
S5	1	1	1	0.698	
min	1	0.880	0.376	0	0

- Then calculate the weights and normalize the weight vectors so that the main criteria weight values are known.

Table 20. Normalized Alternative Weight Vector

	W'	W
F	1	0.443
L	0.88	0.39
C	0.376	0.167
P	0	0
S	0	0

5. Conclusion

The result of this research is to conduct the weight or order of each criteria or alternative so we can prioritize one aspect more than other aspects. So the first weight or order of criteria is demand, the second order is cost, the third order is lead time, the fourth order is life time and the last order is annual usage. The first weight or order of alternative is film, the second order is layer, the third order is chemical and the fourth order is packaging and supported inventory.

References

- Gupta, Sushil dan Star, Martin. Production and Operations Management Systems, United States of America: CRC Press, 2014.
- Mulyanti, Desi, Analisis Pengendalian Persediaan Buah Segar Pada Hipermarket Giant Poin Lebak Bulus". Jakarta. 2011.
- Nag, K dan Helal, M., Multicriteria Inventory Classification of Diabetes Drugs Using a Comparison of AHP and Fuzzy AHP Models, Kuwait'. 2019.
- Reid dan Sanders, Operations Management 5th Edition. United State of America: Wiley.2012.
- Slack, Nigel, Operations Management 7th Edition. United Kingdom: Pearson.2013.
- Wulansari, Septia, OptimasiPersediaanUntukProduk Perishable, Yogyakarta.2017.

Biographies

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