

Sea Cucumber Suppliers Selection Using Multi – Objective Optimization on The Basis of Ratio Analysis Methods

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Abstract. This study aims to implement decision making methodology to select raw material suppliers for sea cucumbers in fish cracker Micro, Small and Medium Enterprises (MSMEs) in Bangkalan Districts, Indonesia. Raw materials sourcing is one of the most critical functions in MSMEs because of its significant effect in reducing production costs and increasing overall profits. The sea cucumbers suppliers' selection process is analysed in two phases. The first phase is the development of a hierarchy of problems in selecting fish cracker MSMEs suppliers to determine the selection criteria and sub-criteria. The Analytical Hierarchy Process (AHP) was used to determine pairwise comparisons, consistent weights and priority decisions of the alternative raw materials suppliers. In the second phase, Multi – Objective Optimization on The Basis of Ratio Analysis (MOORA) is conducted using the AHP results as input to optimize two or more conflicting objectives subject to some constraints. Then, the AHP method and the MOORA method were used to obtain the MSME's sea cucumber suppliers ranking and evaluate the best possible suppliers.

Keywords. Sea Cucumber, MSMEs AHP, MOORA

1 Introduction

Raw material suppliers' selection is essential since raw materials are one of the critical factors in the production process [1]. Furthermore, raw material suppliers directly affect the finished product. If the supplier cannot deliver their products in the duration require by the purchasing department, the production process will stop due to raw materials unavailability from the overextended delivery times [2].

This research studied the MSMEs that produce traditional fish crackers in Bangkalan district, Indonesia. The main ingredient used in making fish crackers is sea cucumbers. Sometimes they can process 50 kg of sea cucumbers, and in a month, they can procure up to 1500 kg of sea cucumbers. These MSMEs strive to improve their performance by selecting the appropriate raw material suppliers.

Table 1. Suppliers and prices of raw materials for sea cucumbers.

Supplier's name	Price (per kg)
Martono	IDR 50,000-60,000
Sido Makmur	IDR 60,000-65,000
Dharma	IDR 50,000-65,000
Melati Mekar	IDR 65,000-70,000

The table above shows the selling price of each raw materials supplier for Bu Musidah, one of a well-known

Fish Cracker producer. The MSME sometimes buy raw materials at high prices, experiences a prolonged delivery of raw materials, incorrect amounts of raw materials, and low-quality sea cucumbers. To compensate for those problems, the MSME procures raw materials from other suppliers so that the production process can continue, even though the suppliers put a higher price. Therefore, the MSMEs need to select the appropriate supplier and avoid the dire consequences of procuring from the poor-performing suppliers [3].

Supplier selection problems can be solved with the methods found in decision-making analysis [4]. One of the methods used is the Analytical Hierarchy Process (AHP) and Multi-Objective Optimization on The Basis of Ratio Analysis (MOORA) method [5]. The Multi-Objective Optimization on The Basis of Ratio Analysis (MOORA) method is easy to understand and flexible in separating objects to the decision weight criteria of the evaluation process [6]. The MOORA method also has a good level of selectivity because it can determine conflicting objectives and criteria, namely criteria that bring benefit or introduce a cost [7]. In addition, the MOORA method results are more accurate and focused on helping decision-making and are easy to implement [8]. In comparison, the AHP method is used to calculate the weights and determine the criteria and sub-criteria used in the MOORA calculation [9, 10].

Based on the description above, it is known that Bu Musidah's Fish Cracker Producer has not found a

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solution to determine the best raw material suppliers for the company. Therefore, the MSME is urged to apply the supplier selection method, using the Multi Objective Optimization on the Basis of Ratio Analysis (MOORA) method.

2 Reserach Methods

2.1 Types of Research

The type of research used is quantitative and qualitative research. Qualitative research uses data regarding supplier selection that includes a weighting assessment of the best supplier criteria. Quantitative analysis is obtained from filling out questionnaires by related parties.

2.2 Criteria and Sub Criteria

The analysis process has built a goal and two levels. There are six main criteria which classified as level 1, and each criterion has its own sub criteria as level 2. Table 2 shows the five original criteria and sub criteria from of the research model which being analyze with pair-wise comparison method using data from respondents.

Table 2. Criteria and sub criteria of the research model

Criteria	Sub criteria
Price	Raw material price
	Discounted price
	Payment
Quality	Specification
	Freshness
	Size
Delivery	Lead time
	Geographic area
	Quantity
Service	Responsibility
	Behaviour
	Service contact
Flexibility	Responsiveness
	Custom quantity order
	Delivery time

2.3 Data Collection Method

1. Interview
2. Questionnaire
3. Literature Study

2.4 Data Processing Method

2.4.1 Data Processing Method Using AHP

1. Define problems and determine solutions to existing problems by compiling a hierarchical structure starting from general goals and criteria and making sorted sub-criteria and alternative choices.

2. Create a pairwise comparison matrix that describes the relative contribution to each goal or criterion at the level above.
3. Normalize the data by dividing the value of each element in the matrix and the total value of each column.
4. Calculate the priority value of the vector obtained from the number of each row
5. Calculating the weights obtained from (prioritas vektor)/(n matriks)
6. Determine the eigenvalue by multiplying the weight obtained from normalization with the total, the first matrix (the total result is called max
7. After calculating max, then look for the consistency index or consistency index (CI) as follows:

$$CI = \frac{\lambda - n}{n - 1} \tag{1}$$

Whereas:

CI = Consistency index

max = eigenvalues

n = number of resulting matrices

8. The consistency ratio (CR) is obtained by comparing the consistency index (CI) with the value of the random index number (RI) as follows:

$$CR = \frac{CI}{RI} \tag{2}$$

Whereas:

CI = Consistency index

RI = Random index

9. Hierarchy consistency test with CR < 0.1

2.4.2 Data Processing Method Using MOORA

1. Decision Matrix
This decision matrix is in the form of data that has been taken during data collection which is made in the form of a matrix
2. Matrix normalization
Matrix normalization is the calculation of the value of each criterion and each alternative supplier of raw material for fish crackers

$$X = [X_{11} X_{12} X_{1n} X_{21} X_{22} X_{2n} X_{m1} X_{m2} X_{mn}] \tag{3}$$

3. Normalization of weighted matrix
Weighted matrix normalization is a calculation based on matrix normalization multiplied by the weights in the data collection.

$$X_{ij} = X_{ij} / \sqrt{\sum_{i=1}^m X_{ij}^2} \tag{4}$$

Whereas:

X_{ij} = alternative matrix j on criterion i

i = 1, 2, 3, ..., n is the sequence number of attributes or criteria

j = 1, 2, 3, ..., m is an alternative sequence number

X_{ij} = alternative normalization matrix j on criterion i

4. Multi-objective optimization, the normalized size is added in the case of maximization for favourable attributes and reduced in minimization (for

unfavourable attributes) or, in other words reducing the maximum and minimum values in each row for ranking in each row.

$$y_i = \sum_{i=1}^g w_j x_{ij} - \sum_{i=g+1}^n w_j x_{ij} \quad (5)$$

Whereas:

$i = 1, 2, \dots, g$ is the criteria/attribute with maximized status status

$i = g+1, g+2, \dots, n$ are criteria/attributes with minimized status

W_j = criterion weight

X_{ij} = normalized matrix value

3 Results and Discussion

3.1 AHP Analysis

A consistency test is a way to find out whether the results of filling out the questionnaire in pairwise comparisons have a value that can be said to be consistent or not. Decision-making is carried out under the following conditions:

CR < 0.10 = Consistent

CR > 0.10 = Inconsistent

Calculating CI (consistency index) with eigenvalue - n matrix / n matrix minus one so that the result is 0.03. RI is adjusted to the RI table, which is 0.58 because it uses the order matrix (3) and then calculates the CR (consistency ratio) resulting from the CI/RI, which is 0.05, not more than 0.1, so it is consistent.

3.2 MOORA Criteria Calculation (Multi Objective Optimization on The Basis of Ratio Analysis)

3.2.2 Matrix Normalization Calculation on Criteria Matrix normalization is calculating the value of each criterion from each supplier. The following is the calculation of each supplier. Normalization of Price criteria matrix for Martono suppliers

$$X_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^m x_{ij}^2}}$$

$$X_{ij} = \frac{Rp \ 53.000}{\sqrt{[53.000^2 + 62.000^2 + 55.000^2 + 65.000^2]}}$$

$$= \frac{53.000}{117.910,98}$$

$$= 0,45$$

The result of the calculation of the normalization of the price criteria matrix on the supplier Martono is 0.45.

3.2.3 Calculation of Weighted Matrix Normalization on Criteria

$$X = [0,45 \ 0,44 \ 0,44 \ 0,53 \ 0,54 \ 0,53 \ 0,55 \ 0,55 \ 0,53 \ 0,54 \ 0,47 \ 0,44 \ 0,44 \ 0,40 \ 0,36 \ 0,55 \ 0,55 \ 0,55 \ 0,53 \ 0,54]$$

Normalization of the Martono supplier weighted matrix

$$y_i = \sum_{i=1}^g w_j x_{ij} - \sum_{i=g+1}^n w_j x_{ij}$$

$$y_i = (X \ 12(max) * W + W + X \ 14(max) * W + X \ 15(max) * W) - (X \ 11(min) * W + X \ 13(max) * W)$$

$$y_i = ((0.44 \times 0.42) + (0.53 \times 0.11) + (0.54 \times 0.13) - (0.45 \times 0.42) + (0.44 \times 0.11))$$

$$y_i = (0.10 + 0.06 + 0.07) - (0.19 + 0.05)$$

$$y_i = 0.23 - 0.24$$

$$= 0.01$$

The result of the normalization of the weighted matrix on the Martono supplier is 0.01

Table 3. Recap of the calculation results of the weighted matrix normalization for each supplier

Supplier	Maximum (Quality, Service, Flexibility)	Minimum (Price, Delivery)	Yi (Max - Min)	Rank
Martono	0.23	0.24	0.00	1
Sido Makmur	0.26	0.28	-0.02	2
Dharma	0.19	0.24	-0.05	4
Melati Mekar	0.26	0.29	-0.03	3

3.2.3 Ranking of Suppliers on Criteria

This ranking will determine which supplier will be selected for Bu Musidah's fish cracker SMEs. Here are the results of the supplier rankings:

Table 4. Ranks of Each Supplier

Supplier	Rank
Martono	1
Sido Makmur	2
Dharma	4
Melati Mekar	3

The table results are the ranking of each supplier obtained from the weighting calculation using the AHP method and the MOORA method. These results were obtained on the supplier Martono with rank 1; the selection was based on data collection through questionnaires and data processing using AHP and MOORA. The AHP method makes the results of pairwise comparisons and calculates the weight value used for the MOORA method; the AHP method contains criteria and sub-criteria. The criteria include price, quality, delivery, service and flexibility. In the criteria there are sub-criteria, namely the cost of raw materials for each supplier, discounts, payment methods, fish specifications, fish freshness level, fish size, timeliness of delivery, geographical location, the accuracy of delivery numbers, supplier responsibilities, supplier behaviour, ease of contact, time order response, ease of adding and subtracting orders and flexibility of delivery time. From each criterion and sub-criteria, data were collected directly from the MSME owners, and the results were obtained for data processing using the AHP and MOORA methods. These results were obtained at the Martono supplier with rank 1 and the results at the

Sido Makmur supplier are expected to make Bu Musidah Fish Crackers SMEs able to cooperate well through the selection of the best suppliers from the four other suppliers in the selection of raw material suppliers for sea cucumbers.

4 Conclusion

This research uses the Analytical Hierarchy Process (AHP) method criteria and sub-criteria. That generated from the study of the literature and adjust the problems found in the research object. The criteria are price, quality of delivery, service and flexibility. In the criteria there are sub-criteria. The price criterion has sub-criteria such as price of raw materials for each supplier, discounts, payment methods. For quality criterion, the sub criteria are fish specifications, fish freshness level, fish size. The delivery criterion has the sub-criteria such as, timeliness of delivery, geographical location, and the accuracy of the number of deliveries. For service criterion, the sub-criteria are the responsibility of the supplier, the behaviour of the supplier. For flexibility criterion, the sub-criteria are ease of contact, order response time, ease of adding and subtracting orders and flexibility of delivery time.

Decision making using the MOORA (Multi Objective Optimization on The Basis of Ratio Analysis) method is carried out to determine the ranking of each supplier that will be selected later. The calculation of the MOORA method was carried out using a questionnaire related to price, quality, delivery, service and flexibility criteria. Data processing using MOORA goes through stages, namely the results of the questionnaire are entered into the formation of a decision matrix, calculating the normalization of the matrix and the normalization of the weighted matrix and determining the maximum and minimum for each criterion so that a ranking can be carried out on each supplier. Ranking of each supplier obtained from the calculation of weighting using the AHP method and the MOORA method. These results were obtained and concluded that the supplier Martono is the most appropriate raw material suppliers for the Bu Musidah's Fish Cracker Producer.

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