

PERFORMANCE EVALUATION OF BRAN SUPPLIERS WITH ANP AND OMAX METHODS

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Abstract PT ASIMAS is an enterprise that cultivates and sells oyster mushrooms. One of the most crucial materials in the production of oyster mushrooms is bran. PT ASIMAS is currently facing several difficulties in performance evaluation of bran suppliers, such as no clear standards in the performance evaluation process of suppliers and late shipment of bran. The objectives of this research are determining the proper criteria and subcriteria and providing improvement recommendation for the enterprise and bran suppliers. This research determined the weights of criteria and subcriteria using Analytic Network Process (ANP). After that, the performance of bran suppliers were assessed through Scoring System with OMAX. This research eventually resulted in 8 criteria and 14 subcriteria. The results of performance evaluation are as follows: Mr. H (4.9699), Mr. Z (4.3622), and Mr. N (4.0869). This research result also provides 14 improvement recommendations: 7 for the enterprise and 7 for suppliers.

Keywords: performance evaluation of bran suppliers, ANP, scoring system, OMAX, TLS

1. Introduction

PT Agaricus Sido Makmur Sentosa known as PT ASIMAS, is a business enterprise that cultivates and sells oyster mushrooms. In the cultivation of oyster mushrooms, bran is one of the most crucial raw material because it produces nutrients needed for the growth of mushrooms, furthermore, bran also has a brief lifetime. PT ASIMAS has several bran suppliers, they are Mr. H, Mr. Z, and Mr. N. From those bran suppliers, only one supplier with lowest price yet highest bran quality selected to fulfill the enterprise's needs of bran.

There are several problems regarding supplier performance evaluation that the enterprise is constantly dealing with, such as no clear standards of performance evaluation process that is based on the proper criteria and subcriteria. Besides, there is also a late shipment of bran that occurs frequently. The data regarding late shipment of bran can be seen in Table 1.

Recently, PT ASIMAS has already maintained a cooperative relationship with bran suppliers, however, they still don't have a structured performance evaluation methods

which are based on required criteria and subcriteria. Thus, performance evaluation of suppliers is necessary to be implemented because the result of performance evaluation would be used as evaluation materials to improve the performance and also as consideration for the enterprise in maintaining long-term and medium-term cooperations with its suppliers. Analytic Network Process (ANP) and Scoring System with Objective Matrix (OMAX) method and Traffic Light System are feasible tools to measure the performance achievement of suppliers.

Table 1. Late Shipment of Bran

Bran Supplier	Period			
	Sep'15	Oct'15	Nov'15	Dec'15
Mr. H	0 day	0 day	2 days	1 day
Mr. Z	2 days	0 day	0 day	0 day
Mr. N	1 day	1 day	0 day	0 day

ANP is possible for the enterprise to manage all types of interrelationships and linkages among the criteria within decision-making system, for instance the price criteria are interrelated with quality criteria [1]. In this research, ANP is used to determine the weights of each criteria and subcriteria. OMAX is a method that observes measurement matrix from the existing performance indicators by consolidating the matrix into a single measure [2]. This model

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was first introduced in the US and it relates directly to all conditions to measure its work performance [3]. OMAX is used to evaluate the performance of suppliers, so the supplier with the results of work performance appraisal by using color indicators such as red (0-3; poor), yellow (4-7; good) and green (8-10; excellent) [5]. Traffic Light System (TLS) is used to find

The use of ANP, OMAX and TLS methods are determining the necessary criteria and subcriteria, evaluating bran suppliers's performance and providing some improvement recommendations for the enterprise and bran suppliers.

2. Research Methods

This research employs descriptive and quantitative approaches. This research report were arranged in four stages: introduction, data collection and processing, analysis and discussion, and conclusion and suggestion.

2.1 Data Collection and Processing Stage

The data was obtained through interviews, questionnaire, and related enterprise documents. The documents consist of primary data and secondary data. Primary data which are the data on suppliers' performance evaluation criteria and subcriteria, level of necessity of each criteria and subcriteria, and the performance evaluation of suppliers. Secondary data is data regarding company profile, mushroom production process, and suppliers' performance achievements.

The procedures of data processing in this research were started with developing linkage models through ANP. The criteria and subcriteria is determined as well as the linkage among criteria and subcriteria that will be used in modelling ANP. Secondly, establishing a paired comparison matrix. Then it followed by calculating the elements' weight which are obtained by normalizing paired comparison matrix and counting up (sum) the elements in one column. After knowing the value of elements's weight, continued to calculate consistency ratio. The next step is developing supermatrix that consists of three stages such as unweighted supermatrix, weighted supermatrix, and limiting supermatrix. Then, Scoring System with OMAX method was evaluating bran suppliers's performance by using TLS. TLS were used to find out whether the performance

the highest performance achievement can be known. Traffic Light System acts as the sign whether the value of an indicator needs improvement or not [4]. This used to evaluate out if bran supplier has achieved the target set by the enterprise and also to evaluate which performance indicator needs to be improved.

indicator needs improvement or not.

2.2 Analysis and Discussion Stage

This stage would consist of analysis and discussion of data processing results. The analysis is conducted at the necessity level of supplier performance evaluation criteria and subcriteria and also the improvement recommendations for the enterprise and suppliers.

2.3 Conclusion and Suggestion Stage

The conclusion and suggestion stage consist of the research conclusions obtained from the result of data collection and processing, result analysis and discussion in response to the determined research objectives.

3. Literature Reviews

This chapter is the elaboration of literature review used in this research.

3.1 Analytic Network Process (ANP)

The procedures of decision-making through ANP are set as follows [6]:

1. Arrange problem structures and develop linkage models. This procedure states the objectives set to achieve. If there are equivalent elements, they will be grouped into the same component.
2. Develop a paired comparison matrix. The paired comparison matrix is conducted by using ANP scale which is from 1 to 9. This comparisons determine the priorities of the choosen elements. The paired comparison would be then transformed into a matrix [7].

$$\begin{matrix} \begin{bmatrix} w_1 & w_1 & \dots & w_1 \\ w_1 & w_2 & \dots & w_n \\ w_2 & w_2 & \dots & w_2 \\ w_1 & w_2 & \dots & w_n \\ \vdots & \dots & \dots & \vdots \\ w_n & w_n & \dots & w_n \\ w_1 & w_2 & \dots & w_n \end{bmatrix} & = & \begin{bmatrix} 1 & a_{12} & \dots & a_{1n} \\ a_{21} & 1 & \dots & a_{2n} \\ \vdots & \dots & \dots & \vdots \\ a_{n1} & a_{n2} & \dots & 1 \end{bmatrix} \end{matrix} \quad (1)$$

To obtain the value of a_{ij} with more than one respondent, data are processed by the geometrical mean formula used as input in Super Decision software.

$$f(x_1, x_2, \dots, x_n) = x_1^{q_1} x_2^{q_2} \dots x_n^{q_n}$$

(2)
Where:

f(x) = geometrical mean

x_n = value given by respondents

q_n = respondent's weight

- Calculate elements' weights. Elements' weights are obtained by normalizing paired comparison matrix and sum those elements into one column.

$$Z_j = \sum_{i=1}^n a_{ij}, \text{ for } j = 1, \dots, n$$

(3)
After that, elements in that matrix are divided by Z_j to result in normalized matrix.

$$w_i = \frac{\sum_{j=1}^n \frac{a_{ij}}{Z_j}}{n}, \text{ for } j = 1, \dots, N$$

- Calculate consistency ratio. Consistency ratio is used to examine the consistency of assessment given by expertise.

$$CI = \frac{\lambda_{maks} - n}{n - 1}$$

(5)
Where:

CI = Consistency Index

λ_{maks} = The greatest eigen value

n = Amount of elements

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

(6)
Where:

CR = Consistency Ratio

CI = Consistency Index

RI = Random Index

- Develop supermatrix. Supermatrix consists of three stages which are Unweighted Supermatrix, Weighted Supermatrix, and Limiting Supermatrix.

3.2 Objective Matrix (OMAX)

The procedures in arranging Objective Matrix (OMAX) are as follows [8]:

- Identification of major criteria and measurement models suitable for the criteria.
- The level of performance before the research conducted is set on level 3 and level 10 is the target the enterprise wants to achieve.
- The performance objectives of each criteria are determined based on the enterprise's target.
- By using linear scale, the levels of achievements would be determined and filled between level 3 and level 10.

$$\Delta X_{L-H} = \frac{Y_H - Y_L}{X_H - X_L} \quad (\text{eq.7})$$

Where:

ΔX_{L-H} = Interval between level high and low

X_H = Level high

X_L = Level low

Y_H = Number at level high

Y_L = Number at level low

- Weighting is done for each performance parameter with the amount of 1.
- The actual result for each criteria or parameter is calculated and set on the "performance" row.
- The level row is filled with association result of "performance" with level from 0 - 10.
- Each level is multiplied by the criteria weight to obtain the value for "value".
- The sum of all "value" is performance index.

Table 2. Criteria and Subcriteria of Suppliers'

No.	Criteria	Subcriteria
1.	Cost	Raw materials offering price
2.		Raw materials negotiation price
3.	Quality	Raw materials quality
4.	Delivery	Punctuality of raw materials shipment
5.		Accuracy of raw materials shipped
6.		Flexibility of changes in raw materials shipment
7.	Responsiveness and Flexibility	Flexibility of changes in raw materials delivery time
8.		Speed of needs fulfillment
9.	Technical Capability	Ability to provide raw materials
10.	Prosedural Compliance	Accessibility to complain
11.		Complaints responsiveness
12.	Communication System	Intensity of information exchanges
13.		Accessibility of communication
14.	Geographical Localtion	Distance to suppliers' location

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4. Result And Discussion

This chapter elaborates the result and discussion of this research.

4.1 Criteria and Subcriteria Identification

Criteria and subcriteria identification process is performed through interview and questionnaires. The criteria and subcriteria of suppliers' performance evaluation can be seen in Table 2.

4.2 Computation with Analytic Network Process (ANP) Method

The computation procedures with ANP method is aimed to determine the ANP linkage model by determining the causal relationship between the criteria. The decision of a causal relationship is conducted by distributing questionnaires regarding causal relationship

among subcriteria. The ANP linkage model can be seen in Figure 1.

The weight value normalized by the cluster is used to find out local weight of each subcriteria, while limiting value is used to find out the global weight of each subcriteria. From those two weights, global weight from limiting value is the one used to compute suppliers' performance value. The weighting result from each criteria can be seen in Table 4 while the weighting result of each subcriteria can be seen in Table 5.

From Table 3, it can be seen that Cost has the greatest weight with 0.20620. It means that cost is the most important criteria. Geographical Location has the smallest weight with 0.01750 which means that it is the least prioritized criteria in the performance evaluation of bran suppliers.

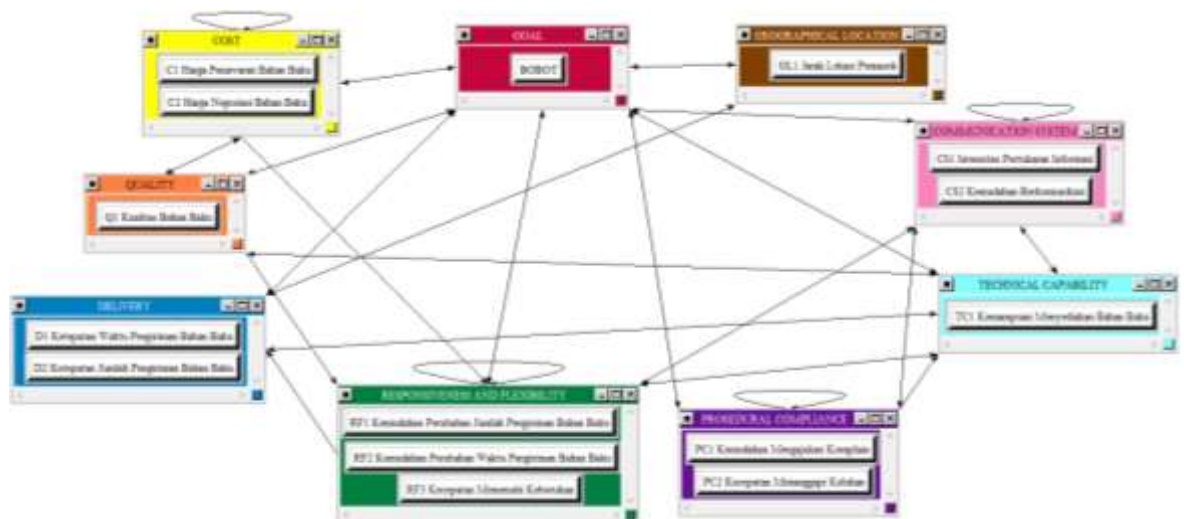


Figure 1. ANP Linkage Model

Table 3. The Weights of Suppliers' Performance Evaluation Criteria

Criteria	Weight
COST	0,20620
QUALITY	0,15172
DELIVERY	0,08319
RESPONSIVENESS AND FLEXIBILITY	0,15135
TECHNICAL CAPABILITY	0,20211
PROSEDURAL COMPLIANCE	0,04216
COMMUNICATION SYSTEM	0,14577
GEOGRAPHICAL LOCATION	0,01750

Table 4. The Weights of Suppliers' Performance Evaluation Subcriteria

Subcriteria	Weight
C1 Raw Materials Offering Price	0,07459
C2 Raw Materials Negotiation Price	0,13161
Q1 Raw Materials Quality	0,15172
D1 Punctuality of raw Materials Shipment	0,04050

Subcriteria	Weight
D2 Accuracy of the Amount of Raw Materials Shipped	0,04269
RF1 Flexibility of Changes in the Amount of Raw Materials Shipped	0,07976
RF2 Flexibility of Changes in Raw Materials Delivery Time	0,01724
RF3 Speed of Needs Fulfillment	0,05435
TC1 Ability to Provide Raw Materials	0,20211
PC1 Accessibility to Complain	0,02706
PC2 Responsiveness of Complaints	0,01510
CS1 Intensity of Information Exchanges	0,04799
CS2 Accessibility of Communication	0,09778
GL1 Suppliers' Location Distance	0,01750

From Table 4, it can be seen that "Ability to Provide Raw Materials" subcriteria has the greatest weight with 0.20211 which means that it is the most prioritized subcriteria.

4.3 Scoring System Computation with

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Objective Matrix (OMAX)

In the computation of OMAX, suppliers' performance evaluation subcriteria is used as the performance indicators and classified into two types which are quantitative and qualitative indicators. The qualitative indicator is assessed in accordance with supplier performance achievement data obtained from the enterprise, while the qualitative indicator is based on the questionnaire data regarding supplier performance evaluation with Likert scale (1-5) as set by the enterprise. Suppliers' performance achievement data is the result of the average of suppliers' performance achievement during two periods which are September - October 2015 and November - December 2015. The

performance achievement of Mr. H, Mr. Z, and Mr. N can be seen in Table 5, Table 6, and Table 7.

The computation procedure with OMAX is to calculate the interval value from the highest, medium, and lowest level with scale linear. The computation is performed for all performance indicators before calculating the value of level, weight, value and index which are the sum of all values from each performance indicator which is then inserted into OMAX matrix. The performance evaluation scheme of Mr. H, Mr. Z, and Mr. N can be seen in Table 8, Table 9, and Table 10.

Table 5. Performance Achievement of Mr. H

Mr. H (Srigading)							
Performance Indicator Code	Suppliers' Performance Achievement Data		Suppliers' Performance Achievement Target	The Worst Supplier's Performance	Unit	Achievement Target Details	Explanation
	Sep 2015 - Oct 2015	Nov 2015 - Dec 2015					
C1	4	4,5	5	1	Scale	Larger is better	Not Achieved
C2	4	4,5	5	1	Scale	Larger is better	Not Achieved
Q1	92	91	95	70	%	Larger is better	Not Achieved
D1	0	1,5	0	7	Day	Smaller is better	Not Achieved
D2	95,5	95	100	90	%	Larger is better	Not Achieved
RF1	4	3,5	5	1	Scale	Larger is better	Not Achieved
RF2	4	3,5	5	1	Scale	Larger is better	Not Achieved
RF3	4	3,5	5	1	Scale	Larger is better	Not Achieved
TC1	95	90	100	50	%	Larger is better	Not Achieved
PC1	5	5	5	1	Scale	Larger is better	Achieved
PC2	5	5	5	1	Scale	Larger is better	Achieved
CS1	5	5	5	1	Scale	Larger is better	Achieved
CS2	5	5	5	1	Scale	Larger is better	Achieved
GL1	5	5	5	1	Scale	Larger is better	Achieved

Table 6. Performance Achievement of Mr. Z

Mr. Z (Singosari)							
Performance Indicator Code	Suppliers' Performance Achievement Data		Suppliers' Performance Achievement Target	The Worst Supplier's Performance	Unit	Achievement Target Details	Explanation
	Sep 2015 - Oct 2015	Nov 2015 - Dec 2015					
C1	3	3	5	1	Scale	Larger is better	Not Achieved
C2	3,5	2,5	5	1	Scale	Larger is better	Not Achieved
Q1	92,5	90,5	95	70	%	Larger is better	Not Achieved
D1	1	0	0	7	Day	Smaller is better	Achieved
D2	97,5	96,5	100	90	%	Larger is better	Not Achieved
RF1	5	4	5	1	Scale	Larger is better	Not Achieved
RF2	5	4	5	1	Scale	Larger is better	Not Achieved
RF3	5	4	5	1	Scale	Larger is better	Not Achieved
TC1	100	97,5	100	50	%	Larger is better	Not Achieved
PC1	4,5	5	5	1	Scale	Larger is better	Achieved
PC2	4,5	5	5	1	Scale	Larger is better	Achieved
CS1	5	5	5	1	Scale	Larger is better	Achieved
CS2	5	5	5	1	Scale	Larger is better	Achieved
GL1	5	5	5	1	Scale	Larger is better	Achieved

Table 7. Performance Achievement of Mr. N

Mr. N (Purwodadi)							
Performance Indicator Code	Suppliers' Performance Achievement Data		Suppliers' Performance Achievement Target	The Worst Supplier's Performance	Unit	Achievement Target Details	Explanation
	Sep 2015 - Oct 2015	Nov 2015 - Dec 2015					
C1	3	3	5	1	Scale	Larger is better	Not Achieved
C2	3,5	2,5	5	1	Scale	Larger is better	Not Achieved
Q1	91	90	95	70	%	Larger is better	Not Achieved
D1	1	0	0	7	Day	Smaller is better	Achieved

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Mr. N (Purwodadi)							
Performance Indicator Code	Suppliers' Performance Achievement Data		Suppliers' Performance Achievement Target	The Worst Supplier's Performance	Unit	Achievement Target Details	Explanation
	Sep 2015 - Oct 2015	Nov 2015 - Dec 2015					
D2	90	90	100	90	%	Larger is better	Not Achieved
RF1	4,5	4	5	1	Scale	Larger is better	Not Achieved
RF2	4,5	4	5	1	Scale	Larger is better	Not Achieved
RF3	4,5	4	5	1	Scale	Larger is better	Not Achieved
TC1	95	92,5	100	50	%	Larger is better	Not Achieved
PC1	4	5	5	1	Scale	Larger is better	Achieved
PC2	5	5	5	1	Scale	Larger is better	Achieved
CS1	4,5	4	5	1	Scale	Larger is better	Not Achieved
CS2	4,5	5	5	1	Scale	Larger is better	Achieved
GL1	5	5	5	1	Scale	Larger is better	Achieved

Table 8. Performance Evaluation Scheme of Mr. H

Mr. H															
Performance Indicator	C1	C2	Q1	D1	D2	RF1	RF2	RF3	TC1	PC1	PC2	CS1	CS2	GL1	
Performance	4,5	4,5	91	1,5	95	3,5	3,5	3,5	90	5	5	5	5	5	
Unit	Scale	Scale	%	Day	%	Scale	Scale	Scale	%	Scale	Scale	Scale	Scale	Scale	
LEVEL	10	5	5	95	0	100	5	5	5	100	5	5	5	5	
	9	4,86	4,86	94,57	0	99,36	4,86	4,86	4,86	99,29	5	5	5	5	
	8	4,71	4,71	94,14	0	98,71	4,71	4,71	4,71	98,57	5	5	5	5	
	7	4,57	4,57	93,71	0	98,07	4,57	4,57	4,57	97,86	5	5	5	5	
	6	4,43	4,43	93,29	0	97,43	4,43	4,43	4,43	97,14	5	5	5	5	
	5	4,29	4,29	92,86	0	96,79	4,29	4,29	4,29	96,43	5	5	5	5	
	4	4,14	4,14	92,43	0	96,14	4,14	4,14	4,14	95,71	5	5	5	5	
	3	4	4	92	0	95,5	4	4	4	95	5	5	5	5	
	2	3	3	84,67	2,33	93,67	3	3	3	80	3,67	3,67	3,67	3,67	3,67
	1	2	2	77,33	4,67	91,83	2	2	2	65	2,33	2,33	2,33	2,33	2,33
0	1	1	70	7	90	1	1	1	50	1	1	1	1	1	
Level	6,5	6,5	2,86	2,64	2,73	2,5	2,5	2,5	2,67	10	10	10	10	10	
Weight	0,075	0,132	0,152	0,041	0,043	0,080	0,017	0,054	0,202	0,027	0,015	0,048	0,098	0,018	
Value	0,485	0,855	0,434	0,107	0,116	0,199	0,043	0,136	0,539	0,271	0,151	0,480	0,978	0,175	
Index	4,9699														

Table 9. Performance Evaluation Scheme of Mr. Z

Mr. Z															
Performance Indicator	C1	C2	Q1	D1	D2	RF1	RF2	RF3	TC1	PC1	PC2	CS1	CS2	GL1	
Performance	3	2,5	90,5	0	96,5	4	4	4	97,5	5	5	5	5	5	
Unit	Scale	Scale	%	Day	%	Scale	Scale	Scale	%	Scale	Scale	Scale	Scale	Scale	
LEVEL	10	5	5	95	0	100	5	5	5	100	5	5	5	5	
	9	4,71	4,79	94,64	0,14	99,64	5	5	5	100	4,93	4,93	5	5	
	8	4,43	4,57	94,29	0,29	99,29	5	5	5	100	4,86	4,86	5	5	
	7	4,14	4,36	93,93	0,43	98,93	5	5	5	100	4,79	4,79	5	5	
	6	3,86	4,14	93,57	0,57	98,57	5	5	5	100	4,71	4,71	5	5	
	5	3,57	3,93	93,21	0,71	98,21	5	5	5	100	4,64	4,64	5	5	
	4	3,29	3,71	92,86	0,86	97,86	5	5	5	100	4,57	4,57	5	5	
	3	3	3,5	92,5	1	97,5	5	5	5	100	4,5	4,5	5	5	
	2	2,33	2,67	85	3	95	3,67	3,67	3,67	83,33	3,33	3,33	3,67	3,67	3,67
	1	1,67	1,83	77,5	5	92,5	2,33	2,33	2,33	66,67	2,17	2,17	2,33	2,33	2,33
0	1	1	70	7	90	1	1	1	50	1	1	1	1	1	
Level	3	1,8	2,73	10	2,6	2,25	2,25	2,25	2,85	10	10	10	10	10	
Weight	0,075	0,132	0,152	0,041	0,043	0,080	0,017	0,054	0,202	0,027	0,015	0,048	0,098	0,018	
Value	0,224	0,237	0,415	0,405	0,111	0,179	0,039	0,122	0,576	0,271	0,151	0,480	0,978	0,175	
Index	4,3622														

Table 10. Performance Evaluation Scheme of Mr. N

Mr. N (Purwodadi)														
Performance Indicator	C1	C2	Q1	D1	D2	RF1	RF2	RF3	TC1	PC1	PC2	CS1	CS2	GL1
Performance	3	2,5	90	0	90	4	4	4	92,5	5	5	4	5	5
Unit	Scale	Scale	%	Day	%	Scale	Scale	Scale	%	Scale	Scale	Scale	Scale	Scale
LEVEL	10	5	5	95	0	100	5	5	5	100	5	5	5	5
	9	4,71	4,79	94,43	0,14	98,57	4,93	4,93	4,93	99,29	4,86	5	4,93	4,93
	8	4,43	4,57	93,86	0,29	97,14	4,86	4,86	4,86	98,57	4,71	5	4,86	4,86
	7	4,14	4,36	93,29	0,43	95,71	4,79	4,79	4,79	97,86	4,57	5	4,79	4,79
	6	3,86	4,14	92,71	0,57	94,29	4,71	4,71	4,71	97,14	4,43	5	4,71	4,71
	5	3,57	3,93	92,14	0,71	92,86	4,64	4,64	4,64	96,43	4,29	5	4,64	4,64
	4	3,29	3,71	91,57	0,86	91,43	4,57	4,57	4,57	95,71	4,14	5	4,57	4,57
	3	3	3,5	91	1	90	4,5	4,5	4,5	95	4	5	4,5	4,5

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Mr. N (Purwodadi)														
Performance Indicator	C1	C2	Q1	D1	D2	RF1	RF2	RF3	TC1	PC1	PC2	CS1	CS2	GL1
Performance	3	2,5	90	0	90	4	4	4	92,5	5	5	4	5	5
Unit	Scale	Scale	%	Day	%	Scale	Scale	Scale	%	Scale	Scale	Scale	Scale	Scale
2	2,33	2,67	84	3	90	3,33	3,33	3,33	80	3	3,67	3,33	3,33	3,67
1	1,67	1,83	77	5	90	2,17	2,17	2,17	65	2	2,33	2,17	2,17	2,33
0	1	1	70	7	90	1	1	1	50	1	1	1	1	1
Level	3	1,8	2,86	10	3	2,57	2,57	2,57	2,83	10	10	2,57	10	10
Weight	0,075	0,132	0,152	0,04	0,044	0,080	0,017	0,054	0,202	0,027	0,015	0,048	0,098	0,018
Value	0,224	0,237	0,433	0,41	0,128	0,205	0,044	0,140	0,573	0,271	0,151	0,123	0,978	0,175
Index	4,0869													

4.4 Suppliers' Performance Evaluation with Traffic Light System

Traffic Light System would mark whether a performance indicator needs improvement or not. Performance indicator of Mr. H, Mr. Z, and Mr. N based on Traffic Light System can be seen in Table 11, Table 12, and Table 13.

Table 11. Performance Indicator of Mr. H Based on TLS

Code	Performance Indicator
PC1	Accessibility to Complain
PC2	Responsiveness to Complaints
CS1	Intensity of Information Exchanges
CS2	Accessibility of Communication
GL1	Suppliers' Location Distance
C1	Raw Materials Offering Price
C2	Raw Materials Negotiation Price
Q1	Raw Materials Quality
D1	Punctuality of Raw Materials Shipment
D2	Accuracy of Raw Materials Amount Shipped
RF1	Flexibility in Changes of Raw Materials Amount Shipped
RF2	Flexibility in Changes of Raw Materials Shipment Time
RF3	Speed of Needs Fulfillment
TC1	Ability to Provide Raw Materials

Table 12. Performance Indicator of Mr. Z Based on TLS

Code	Performance Indicator
D1	Punctuality of Raw Materials Shipment
PC1	Accessibility to Complain
PC2	Responsiveness to Complaints
CS1	Intensity of Information Exchanges
CS2	Accessibility of Communication
GL1	Suppliers' Location Distance
C1	Raw Materials Offering Price
C2	Raw Materials Negotiation Price
Q1	Raw Materials Quality
D2	Accuracy of Raw Materials Amount Shipped
RF1	Flexibility in Changes of Raw Materials Amount Shipped
RF2	Flexibility in Changes of Raw Materials Shipment Time
RF3	Speed of Needs Fulfillment
TC1	Ability to Provide Raw Materials

Table 13. Performance Indicator of Mr. N Based on TLS

Code	Performance Indicator
D1	Punctuality of Raw Materials Shipment
PC1	Accessibility to Complain
PC2	Responsiveness to Complaints
CS2	Accessibility of Communication
GL1	Suppliers' Location Distance
C1	Raw Materials Offering Price
C2	Raw Materials Negotiation Price
Q1	Raw Materials Quality

Code	Performance Indicator
D2	Accuracy of Raw Materials Amount Shipped
RF1	Flexibility in Changes of Raw Materials Amount Shipped
RF2	Flexibility in Changes of Raw Materials Shipment Time
RF3	Speed of Needs Fulfillment
TC1	Ability to Provide Raw Materials
CS1	Intensity of Information Exchanges

Table 11 above shows five green, two yellow, and seven red performance indicators for supplier Mr. H. Table 12 above shows six green and eight red performance indicators for supplier Mr. Z. Table 13 above shows five green and nine red performance indicators for supplier Mr. N.

4.5 Analysis of Criteria Weights

Figure 2 shows that Cost and Technical Capability have relatively equal weights, which are 0.2062 and 0.20211. Those two criteria are considered crucial because the enterprise always wants to minimize the purchasing price of bran and consider the capability of suppliers in providing bran itself.

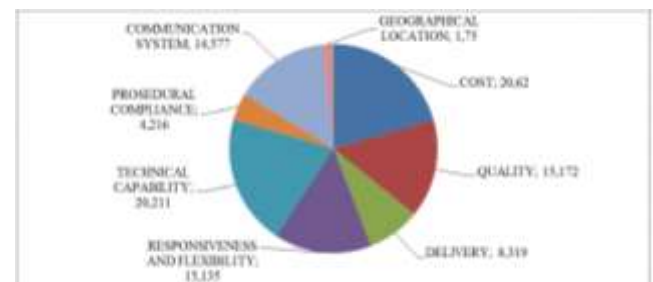


Figure 2. Criteria Weights Comparison of Suppliers' Performance Evaluation

4.6 Analysis of Subcriteria Weights

Table 14 demonstrates that subcriteria of Responsiveness and Flexibility are in the bottom ranks meanwhile Figure 2 shows that criteria of Responsiveness and Flexibility have quite significant weights. This difference is due to the different assessment by respondents when they assessed the weights of criteria and subcriteria [9]. For instance, a respondent assessed that subcriteria "Flexibility in Changes

of Raw Materials Shipment Time” from criteria of Responsiveness and Flexibility doesn’t affect other subcriteria. However, in the criteria weight assessment, criteria of Responsiveness and Flexibility is one of the most crucial criteria in evaluating the performance of suppliers.

Table 14. The Order of Suppliers’ Performance Evaluation Subcriteria

No.	Subcriteria	Subcriteria Weights
1.	Ability to Provide Raw Materials	0,20211
2.	Raw Materials Quality	0,15172
3.	Raw Materials Negotiation Price	0,13161
4.	Accessibility of Communication	0,09778
5.	Flexibility in Changes of Raw Materials Amount Shipped	0,07976
6.	Raw Materials Offering Price	0,07459
7.	Speed of Needs Fulfillment	0,05435
8.	Intensity of Information Exchanges	0,04799
9.	Accuracy of Raw Materials Amount Shipped	0,04269
10.	Punctuality of Raw Materials Shipment	0,04050
11.	Accessibility to Complain	0,02706
12.	Suppliers’ Location Distance	0,01750
13.	Flexibility in Changes of Raw Materials Shipment Time	0,01724
14.	Responsiveness to Complaints	0,01510

4.7 Improvement Recommendation

The red and yellow performance indicators in TLS need to be analyzed with Fishbone diagram in order to find out the causes of the unachieved performance target by referring to the ANP linkage model, so the performance indicator could affect the other indicators. This improvement recommendation

is expected to be the evaluation materials for the bran suppliers in order to improve their performance, and for the enterprise as the consideration material in maintaining medium and long-term cooperation with the suppliers. The result of performance achievement of each supplier can be seen in Figure 3.

Figure 3 shows that the performance of bran suppliers, who are Mr. H, Mr. Z, and Mr. N are yellow-colored which means that the performances of those suppliers are relatively good but they haven’t met the predetermined target. Suppliers should improve their performance and prepare themselves for any possibility that could hinder their performance.

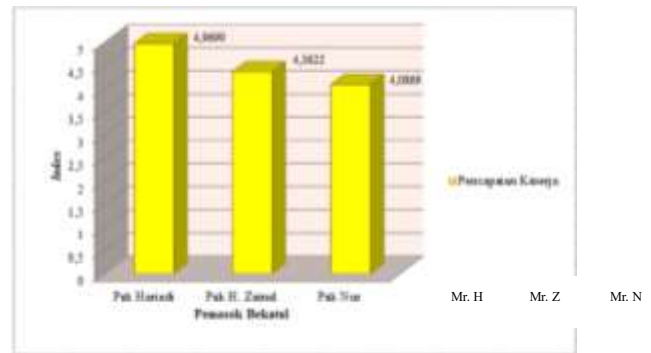


Figure 3. The Performance Achievement Result of Each Bran Supplier

Table 15. Improvement Recommendation for the Enterprise for Performance Indicators

No.	Performance Indicators	Problem Cause	Improvement Recommendation
1.	Raw Materials Offering Price	Rice crop failure	Look for alternative raw materials aside from bran
		Brief lifetime of bran	Monitor the humidity of bran
		The quality of coarse and fine bran mixture	Joint inspection by the enterprise and suppliers
		Planning error	Implement CPFR model
2.	Raw Materials Negotiation Price	Rice crop failure	Look for alternative raw materials aside from bran
		Brief lifetime of bran	Monitor the humidity of bran
		The quality of coarse and fine bran mixture	Joint inspection by the enterprise and suppliers
		Planning error	Implement sharing information
3.	Raw Materials Quality	Rice crop failure	Look for alternative raw materials aside from bran
		Bran is too moist	Monitor the humidity of bran
		The quality of coarse and fine bran mixture	Joint inspection by the enterprise and suppliers
		Lack of rice milling machine maintenance	
4.	Punctuality of Raw Materials Shipment	Planning failure	Implement CPFR model
		Misinformation in bran shipment time	Implement sharing information
5.	Accuracy of Raw Materials Amount Shipped	Rice crop failure	Look for alternative raw materials aside from bran
		Fragile bran sacks	Joint inspection by the enterprise and suppliers
		Planning error	Implement CPFR model
6.	Flexibility in Changes of Raw Materials Amount Shipped	Rice crop failure	Look for alternative raw materials aside from bran
		Planning error	Implement CPFR model
		Misinformation regarding the availability of bran	Implement sharing information
7.	Flexibility in Changes of Raw Materials Shipment Time	Rice crop failure	Look for alternative raw materials aside from bran
		Planning error	Implement CPFR model
		Misinformation in bran shipment time	Implement sharing information

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No.	Performance Indicators	Problem Cause	Improvement Recommendation
8.	Speed of Needs Fulfillment	Rice crop failure	Look for alternative raw materials aside from bran
		Planning error	Implement CPFR model
		Misinformation in bran shipment time	Implement sharing information
9.	Ability to Provide Raw Materials	Rice crop failure	Look for alternative raw materials aside from bran bekatul
		The quality of coarse and fine bran mixture	Joint inspection by the enterprise and suppliers
		Planning error	Implement CPFR model
		Misinformation in bran shipment time	Implement sharing information
10.	Intensity of Information Exchanges	Rice crop failure	Look for alternative raw materials aside from bran
		Planning error	Implement CPFR model
		Misinformation regarding the availability of bran	Implement sharing information

4.7.1 Improvement Recommendations for the Enterprise

Improvement recommendation for the enterprise is based on performance indicators in the TLS evaluation. It can be seen in Table 15.

4.7.2 Improvement Recommendation for Bran Suppliers

Improvement recommendations for bran suppliers are based on performance indicators in the evaluation by using TLS. It can be seen in Table 16.

Table 16. Improvement Recommendation for Bran Suppliers for Performance Indicators

No.	Performance Indicators	Problem Cause	Improvement Recommendation
1.	Raw Materials Offering Price	Rice crop failure	Cooperation with farmer communities
		The quality of coarse and fine bran mixture	Bran quality assessment
		Brief lifetime of bran	Control the humidity of bran
		Planning error	Implement CPFR model
2.	Raw Materials Negotiation Price	Rice crop failure	Cooperation with farmer communities
		The quality of coarse and fine bran mixture	Bran quality assessment
		Brief lifetime of bran	Control the humidity of bran
		Planning error	Implement CPFR model
3.	Raw Materials Quality	Rice crop failure	Cooperation with farmer communities
		The quality of coarse and fine bran mixture	Bran quality assessment
		Bran is too moist	Control the humidity of bran
		Lack of rice milling machine maintenance	Conduct regular maintenance of rice milling machine
4.	Punctuality of Raw Materials Shipment	Planning error	Implement CPFR model
		Error in bran shipment time	Implement sharing information
5.	Accuracy of Raw Materials Amount Shipped	Rice crop failure	Cooperation with farmer communities
		Planning error	Implement CPFR model
		Fragile bran sacks	Improve the bran packaging process
6.	Flexibility in Changes of Raw Materials Amount Shipped	Rice crop failure	Cooperation with farmer communities
		Planning error	Implement CPFR model
		Misinformation regarding the availability of bran	Implement sharing information
7.	Flexibility in Changes of Raw Materials Shipment Time	Rice crop failure	Cooperation with farmer communities
		Planning error	Implement CPFR model
		Misinformation regarding the availability of bran	Implement sharing information
8.	Speed of Needs Fulfillment	Rice crop failure	Cooperation with farmer communities
		Planning error	Implement CPFR model
		Misinformation regarding the availability of bran	Implement sharing information
9.	Ability to Provide Raw Materials	Planning error	Cooperation with farmer communities
		The quality of coarse and fine bran mixture	Bran quality assessment
		Planning error	Implement CPFR model
		Misinformation regarding the availability of bran	Implement sharing information
10.	Intensity of Information Exchanges	Rice crop failure	Cooperation with farmer communities
		Planning error	Implement CPFR model
		Misinformation regarding the availability of bran	Implement sharing information

5. Conclusion

Based on the research conducted, the conclusions are as follows:

1. The weight result of each criteria by using the highest Analytic Network Process (ANP) is Cost (0,2062) and the lowest is Geographical Location

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- (0,0175). The weight result of each subcriteria with the highest result is Ability to Provide Raw Materials (0,20211) while the lowest result is Responsiveness to Complaints (0,01510).
2. The result of suppliers' performance evaluation by using Scoring System dengan Objective Matrix (OMAX) and Traffic Light System is: Mr. H (4,9699), Mr. Z (4,3622), and Mr. N (4,0869).
 3. Improvement recommendations for the enterprise are as follows: search for alternative raw materials aside from bran as the mushroom cultivation medium, control the bran humidity, conduct joint inspection with suppliers, apply CPFR (*collaborative planning, forecasting, and replenishment*) model, apply sharing information, maintain cooperation contract with bran suppliers in accordance with the performance achievement, and apply Risk-Hedging Supply Chain strategy. While the improvement recommendations for bran suppliers are as follows: build cooperation with farmer communities, assess the bran quality, control the bran humidity, regularly maintain the machine, implement CPFR (*collaborative planning, forecasting, and replenishment*) model, implement sharing information, and improve the bran packaging process.

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