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>
<thead>
<tr>
<th>Table 1. Late Shipment of Bran</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bran Supplier</td>
</tr>
<tr>
<td>Mr. H</td>
</tr>
<tr>
<td>Mr. Z</td>
</tr>
<tr>
<td>Mr. N</td>
</tr>
</tbody>
</table>

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
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 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 chosen elements. The paired comparison would be then transformed into a matrix [7].

\[
\begin{bmatrix}
    w_1 & w_2 & \cdots & w_n \\
    w_1 & w_2 & \cdots & w_n \\
    \vdots & \vdots & \ddots & \vdots \\
    w_1 & w_2 & \cdots & w_n \\
\end{bmatrix}
= \begin{bmatrix}
    1 & a_{12} & \cdots & a_{1n} \\
    a_{21} & 1 & \cdots & a_{2n} \\
    \vdots & \vdots & \ddots & \vdots \\
    a_{n1} & a_{n2} & \cdots & 1
\end{bmatrix}
\]

(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.
3.2 Objective Matrix (OMAX)

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

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

\[ \Delta X_{L-H} = \frac{Y_H - Y_L}{X_H - X_L} \]  

(eq.7)

Where:
- \( \Delta X_{L-H} \) = 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

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

### Table 2. Criteria and Subcriteria of Suppliers’

<table>
<thead>
<tr>
<th>No.</th>
<th>Criteria</th>
<th>Subcriteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Cost</td>
<td>Raw materials offering price</td>
</tr>
<tr>
<td>2.</td>
<td></td>
<td>Raw materials negotiation price</td>
</tr>
<tr>
<td>3.</td>
<td>Quality</td>
<td>Raw materials quality</td>
</tr>
<tr>
<td>4.</td>
<td>Delivery</td>
<td>Punctuality of raw materials shipment</td>
</tr>
<tr>
<td>5.</td>
<td></td>
<td>Accuracy of raw materials shipped</td>
</tr>
<tr>
<td>6.</td>
<td>Responsiveness and Flexibility</td>
<td>Flexibility of changes in raw materials shipment</td>
</tr>
<tr>
<td>7.</td>
<td>Responsiveness and Flexibility</td>
<td>Speed of needs fulfillment</td>
</tr>
<tr>
<td>8.</td>
<td></td>
<td>Accessibility to complain</td>
</tr>
<tr>
<td>9.</td>
<td>Technical Capability</td>
<td>Ability to provide raw materials</td>
</tr>
<tr>
<td>10.</td>
<td>Procedural Compliance</td>
<td>Accessibility to complain</td>
</tr>
<tr>
<td>11.</td>
<td></td>
<td>Complaints responsiveness</td>
</tr>
<tr>
<td>12.</td>
<td>Communication System</td>
<td>Intensity of information exchanges</td>
</tr>
<tr>
<td>13.</td>
<td></td>
<td>Accessibility of communication</td>
</tr>
<tr>
<td>14.</td>
<td>Geographical Location</td>
<td>Distance to suppliers’ location</td>
</tr>
</tbody>
</table>
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.

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.

### Table 3. The Weights of Suppliers’ Performance Evaluation Criteria

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Weight</th>
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<tbody>
<tr>
<td>COST</td>
<td>0.20620</td>
</tr>
<tr>
<td>QUALITY</td>
<td>0.15172</td>
</tr>
<tr>
<td>DELIVERY</td>
<td>0.08319</td>
</tr>
<tr>
<td>RESPONSIVENESS AND FLEXIBILITY</td>
<td>0.15135</td>
</tr>
<tr>
<td>TECHNICAL CAPABILITY</td>
<td>0.20211</td>
</tr>
<tr>
<td>PROSEDURAL COMPLIANCE</td>
<td>0.04216</td>
</tr>
<tr>
<td>COMMUNICATION SYSTEM</td>
<td>0.14577</td>
</tr>
<tr>
<td>GEOGRAPHICAL LOCATION</td>
<td>0.01750</td>
</tr>
</tbody>
</table>

### Table 4. The Weights of Suppliers’ Performance Evaluation Subcriteria

<table>
<thead>
<tr>
<th>Subcriterion</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1 Raw Materials Offering Price</td>
<td>0.07459</td>
</tr>
<tr>
<td>C2 Raw Materials Negotiation Price</td>
<td>0.13161</td>
</tr>
<tr>
<td>D1 Raw Materials Quality</td>
<td>0.15172</td>
</tr>
<tr>
<td>D1 Punctuality of raw Materials Shipment</td>
<td>0.04050</td>
</tr>
</tbody>
</table>

4.3 Scoring System Computation with
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 quantitative 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>
<thead>
<tr>
<th>Performance Indicator Code</th>
<th>Suppliers' Performance Achievement Data</th>
<th>Suppliers' Performance Achievement Target</th>
<th>The Worst Supplier's Performance</th>
<th>Unit</th>
<th>Achievement Target Details</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>4 4.5 4 5</td>
<td>1</td>
<td>Scale</td>
<td>Larger is better</td>
<td>Not Achieved</td>
<td></td>
</tr>
<tr>
<td>C2</td>
<td>4 4.5 4 5</td>
<td>1</td>
<td>Scale</td>
<td>Larger is better</td>
<td>Not Achieved</td>
<td></td>
</tr>
<tr>
<td>Q1</td>
<td>92 91 95</td>
<td>70</td>
<td>%</td>
<td>Larger is better</td>
<td>Not Achieved</td>
<td></td>
</tr>
<tr>
<td>D1</td>
<td>0 1.5 0</td>
<td>7</td>
<td>Day</td>
<td>Smaller is better</td>
<td>Not Achieved</td>
<td></td>
</tr>
<tr>
<td>D2</td>
<td>95.5 95 100</td>
<td>90</td>
<td>%</td>
<td>Larger is better</td>
<td>Not Achieved</td>
<td></td>
</tr>
<tr>
<td>RF1</td>
<td>4 3.5 3</td>
<td>1</td>
<td>Scale</td>
<td>Larger is better</td>
<td>Not Achieved</td>
<td></td>
</tr>
<tr>
<td>RF2</td>
<td>4 3.5 3</td>
<td>1</td>
<td>Scale</td>
<td>Larger is better</td>
<td>Not Achieved</td>
<td></td>
</tr>
<tr>
<td>TC1</td>
<td>95 30</td>
<td>50</td>
<td>%</td>
<td>Larger is better</td>
<td>Not Achieved</td>
<td></td>
</tr>
<tr>
<td>PC1</td>
<td>5 3 5</td>
<td>1</td>
<td>Scale</td>
<td>Larger is better</td>
<td>Achieved</td>
<td></td>
</tr>
<tr>
<td>PC2</td>
<td>5 3 5</td>
<td>1</td>
<td>Scale</td>
<td>Larger is better</td>
<td>Achieved</td>
<td></td>
</tr>
<tr>
<td>CS1</td>
<td>5 5 5</td>
<td>1</td>
<td>Scale</td>
<td>Larger is better</td>
<td>Achieved</td>
<td></td>
</tr>
<tr>
<td>CS2</td>
<td>5 5 5</td>
<td>1</td>
<td>Scale</td>
<td>Larger is better</td>
<td>Achieved</td>
<td></td>
</tr>
<tr>
<td>GL1</td>
<td>5 5 5</td>
<td>1</td>
<td>Scale</td>
<td>Larger is better</td>
<td>Achieved</td>
<td></td>
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</tbody>
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<tr>
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<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>3 2 3</td>
<td>1</td>
<td>Scale</td>
<td>Larger is better</td>
<td>Not Achieved</td>
<td></td>
</tr>
<tr>
<td>C2</td>
<td>3.5 2.5 3</td>
<td>1</td>
<td>Scale</td>
<td>Larger is better</td>
<td>Not Achieved</td>
<td></td>
</tr>
<tr>
<td>Q1</td>
<td>92.5 90.5 95</td>
<td>70</td>
<td>%</td>
<td>Larger is better</td>
<td>Not Achieved</td>
<td></td>
</tr>
<tr>
<td>D1</td>
<td>1 0 9</td>
<td>7</td>
<td>Day</td>
<td>Smaller is better</td>
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<tr>
<td>D2</td>
<td>97.5 96.5 100</td>
<td>90</td>
<td>%</td>
<td>Larger is better</td>
<td>Not Achieved</td>
<td></td>
</tr>
<tr>
<td>RF1</td>
<td>5 4 5</td>
<td>1</td>
<td>Scale</td>
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<td></td>
</tr>
<tr>
<td>RF2</td>
<td>5 4 5</td>
<td>1</td>
<td>Scale</td>
<td>Larger is better</td>
<td>Not Achieved</td>
<td></td>
</tr>
<tr>
<td>TC1</td>
<td>100 97.5</td>
<td>50</td>
<td>%</td>
<td>Larger is better</td>
<td>Not Achieved</td>
<td></td>
</tr>
<tr>
<td>PC1</td>
<td>4.5 3</td>
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<td>Scale</td>
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<td>Achieved</td>
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</tr>
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<td>Scale</td>
<td>Larger is better</td>
<td>Achieved</td>
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<tr>
<td>CS2</td>
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<td>Scale</td>
<td>Larger is better</td>
<td>Achieved</td>
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<tr>
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<td>Scale</td>
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<th>Suppliers' Performance Achievement Target</th>
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<th>Unit</th>
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<th>Explanation</th>
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<tbody>
<tr>
<td>C1</td>
<td>3 2 3</td>
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<td>Scale</td>
<td>Larger is better</td>
<td>Not Achieved</td>
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<td>C2</td>
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<td>Scale</td>
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</tr>
<tr>
<td>Q1</td>
<td>91 90 95</td>
<td>70</td>
<td>%</td>
<td>Larger is better</td>
<td>Not Achieved</td>
<td></td>
</tr>
<tr>
<td>D1</td>
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<td>7</td>
<td>Day</td>
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<td>Achieved</td>
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### Table 8. Performance Evaluation Scheme of Mr. H

<table>
<thead>
<tr>
<th>Performance Indicator</th>
<th>C1</th>
<th>C2</th>
<th>Q1</th>
<th>D1</th>
<th>D2</th>
<th>RF1</th>
<th>RF2</th>
<th>RF3</th>
<th>TC1</th>
<th>PC1</th>
<th>PC2</th>
<th>CS1</th>
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### Table 9. Performance Evaluation Scheme of Mr. Z

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<th>C2</th>
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<th>D1</th>
<th>D2</th>
<th>RF1</th>
<th>RF2</th>
<th>RF3</th>
<th>TC1</th>
<th>PC1</th>
<th>PC2</th>
<th>CS1</th>
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<td>0.019</td>
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### Table 10. Performance Evaluation Scheme of Mr. N

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<th>Performance Indicator</th>
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<th>C2</th>
<th>Q1</th>
<th>D1</th>
<th>D2</th>
<th>RF1</th>
<th>RF2</th>
<th>RF3</th>
<th>TC1</th>
<th>PC1</th>
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<td>0.041</td>
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### Table 1. Performance Indicator of Mr. H Based on TLS

<table>
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<th>Index</th>
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</thead>
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<tr>
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<td>Accessibility of Communication</td>
<td>0.140</td>
<td>0.280</td>
<td>0.280</td>
</tr>
<tr>
<td>GL1</td>
<td>Suppliers’ Location Distance</td>
<td>0.015</td>
<td>0.030</td>
<td>0.030</td>
</tr>
<tr>
<td>C1</td>
<td>Raw Materials Offering Price</td>
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<td>0.168</td>
<td>0.168</td>
</tr>
<tr>
<td>C2</td>
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</tr>
<tr>
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<tr>
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### Table 2. Performance Indicator of Mr. Z Based on TLS

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</tr>
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<tr>
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<td>0.168</td>
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<tr>
<td>CS2</td>
<td>Responsiveness to Complaints</td>
<td>0.140</td>
<td>0.280</td>
<td>0.280</td>
</tr>
<tr>
<td>CS3</td>
<td>Intensity of Information Exchanges</td>
<td>0.044</td>
<td>0.088</td>
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</tr>
<tr>
<td>CS4</td>
<td>Accessibility of Communication</td>
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<td>0.280</td>
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</tr>
<tr>
<td>GL1</td>
<td>Suppliers’ Location Distance</td>
<td>0.015</td>
<td>0.030</td>
<td>0.030</td>
</tr>
<tr>
<td>C1</td>
<td>Raw Materials Offering Price</td>
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<td>0.088</td>
<td>0.088</td>
</tr>
<tr>
<td>C2</td>
<td>Raw Materials Negotiation Price</td>
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<tr>
<td>Q1</td>
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</tr>
<tr>
<td>D1</td>
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<tr>
<td>D2</td>
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<tr>
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<td>0.015</td>
<td>0.030</td>
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<tr>
<td>RF3</td>
<td>Speed of Needs Fulfillment</td>
<td>0.015</td>
<td>0.030</td>
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</tr>
<tr>
<td>TC1</td>
<td>Ability to Provide Raw Materials</td>
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### Table 3. Performance Indicator of Mr. N Based on TLS

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<td>0.088</td>
</tr>
<tr>
<td>CS2</td>
<td>Responsiveness to Complaints</td>
<td>0.044</td>
<td>0.088</td>
<td>0.088</td>
</tr>
<tr>
<td>CS3</td>
<td>Intensity of Information Exchanges</td>
<td>0.044</td>
<td>0.088</td>
<td>0.088</td>
</tr>
<tr>
<td>CS4</td>
<td>Accessibility of Communication</td>
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<td>0.088</td>
<td>0.088</td>
</tr>
<tr>
<td>GL1</td>
<td>Suppliers’ Location Distance</td>
<td>0.044</td>
<td>0.088</td>
<td>0.088</td>
</tr>
<tr>
<td>C1</td>
<td>Raw Materials Offering Price</td>
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<td>0.088</td>
<td>0.088</td>
</tr>
<tr>
<td>C2</td>
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<td>0.088</td>
<td>0.088</td>
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<td>0.088</td>
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<tr>
<td>D1</td>
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<td>0.088</td>
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<tr>
<td>RF3</td>
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<td>0.044</td>
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<td>0.088</td>
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<tr>
<td>TC1</td>
<td>Ability to Provide Raw Materials</td>
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<td>0.088</td>
<td>0.088</td>
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</table>

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

<table>
<thead>
<tr>
<th>Code</th>
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<th>Weight</th>
<th>Scale</th>
<th>Index</th>
</tr>
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<tbody>
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<td>PC1</td>
<td>Accessibility to Complain</td>
<td>0.075</td>
<td>1.125</td>
<td>0.098</td>
</tr>
<tr>
<td>CS2</td>
<td>Responsiveness to Complaints</td>
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<td>0.088</td>
<td>0.088</td>
</tr>
<tr>
<td>CS3</td>
<td>Intensity of Information Exchanges</td>
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</tr>
<tr>
<td>CS4</td>
<td>Accessibility of Communication</td>
<td>0.140</td>
<td>0.280</td>
<td>0.280</td>
</tr>
<tr>
<td>GL1</td>
<td>Suppliers’ Location Distance</td>
<td>0.015</td>
<td>0.030</td>
<td>0.030</td>
</tr>
<tr>
<td>C1</td>
<td>Raw Materials Offering Price</td>
<td>0.084</td>
<td>0.168</td>
<td>0.168</td>
</tr>
<tr>
<td>C2</td>
<td>Raw Materials Negotiation Price</td>
<td>0.044</td>
<td>0.088</td>
<td>0.088</td>
</tr>
<tr>
<td>Q1</td>
<td>Raw Materials Quality</td>
<td>0.016</td>
<td>0.032</td>
<td>0.032</td>
</tr>
<tr>
<td>D1</td>
<td>Punctuality of Raw Materials Shipment</td>
<td>0.140</td>
<td>0.280</td>
<td>0.280</td>
</tr>
<tr>
<td>D2</td>
<td>Accuracy of Raw Materials Amount Shipped</td>
<td>0.015</td>
<td>0.030</td>
<td>0.030</td>
</tr>
<tr>
<td>RF1</td>
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<td>0.280</td>
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<tr>
<td>RF2</td>
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<td>0.030</td>
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</tr>
<tr>
<td>RF3</td>
<td>Speed of Needs Fulfillment</td>
<td>0.015</td>
<td>0.030</td>
<td>0.030</td>
</tr>
<tr>
<td>TC1</td>
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Table 12. Performance Indicator of Mr. Z Based on TLS

<table>
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<th>Weight</th>
<th>Scale</th>
<th>Index</th>
</tr>
</thead>
<tbody>
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<td>0.168</td>
<td>0.168</td>
</tr>
<tr>
<td>CS2</td>
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<tr>
<td>CS3</td>
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<td>0.088</td>
</tr>
<tr>
<td>C1</td>
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<td>0.088</td>
<td>0.088</td>
</tr>
<tr>
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<td>0.088</td>
<td>0.088</td>
</tr>
<tr>
<td>Q1</td>
<td>Raw Materials Quality</td>
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<td>0.088</td>
<td>0.088</td>
</tr>
<tr>
<td>D1</td>
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<td>0.088</td>
<td>0.088</td>
</tr>
<tr>
<td>D2</td>
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<td>0.088</td>
<td>0.088</td>
</tr>
<tr>
<td>RF1</td>
<td>Flexibility in Changes of Raw Materials Amount Shipped</td>
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<tr>
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</tr>
<tr>
<td>TC1</td>
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<td>0.088</td>
<td>0.088</td>
</tr>
</tbody>
</table>

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.

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..."
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 Subcriterias

<table>
<thead>
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<th>No.</th>
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<td>1</td>
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</tr>
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<td>2</td>
<td>Raw Materials Quality</td>
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</tr>
<tr>
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</tr>
<tr>
<td>4</td>
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<tr>
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<tr>
<td>14</td>
<td>Responsiveness to Complaints</td>
<td>0,01510</td>
</tr>
</tbody>
</table>

### 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.

### Table 15. Improvement Recommendation for the Enterprise for Performance Indicators

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

<table>
<thead>
<tr>
<th>No.</th>
<th>Performance Indicators</th>
<th>Problem Cause</th>
<th>Improvement Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Raw Materials Offering Price</td>
<td>Rice crop failure</td>
<td>Cooperation with farmer communities</td>
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<tr>
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<td>The quality of coarse and fine bran mixture</td>
<td>Bran quality assessment</td>
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<td></td>
<td>Brief lifetime of bran</td>
<td>Control the humidity of bran</td>
</tr>
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<td>Implement CPFR model</td>
</tr>
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</tr>
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<td>The quality of coarse and fine bran mixture</td>
<td>Bran quality assessment</td>
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<tr>
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<td>Brief lifetime of bran</td>
<td>Control the humidity of bran</td>
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<td>Implement CPFR model</td>
</tr>
<tr>
<td>3.</td>
<td>Raw Materials Quality</td>
<td>Rice crop failure</td>
<td>Cooperation with farmer communities</td>
</tr>
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<td></td>
<td></td>
<td>The quality of coarse and fine bran mixture</td>
<td>Bran quality assessment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Brief lifetime of bran</td>
<td>Control the humidity of bran</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lack of rice milling machine maintenance</td>
<td>Conduct regular maintenance of rice milling machine</td>
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<td>Cooperation with farmer communities</td>
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<td>Fragile bran sacks</td>
<td>Improve the bran packaging process</td>
</tr>
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<td>Rice crop failure</td>
<td>Cooperation with farmer communities</td>
</tr>
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<td></td>
<td>Planning error</td>
<td>Implement CPFR model</td>
</tr>
<tr>
<td></td>
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<td>Misinformation regarding the availability of bran</td>
<td>Implement sharing information</td>
</tr>
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<td>7.</td>
<td>Flexibility in Changes of Raw Materials Shipment Time</td>
<td>Rice crop failure</td>
<td>Cooperation with farmer communities</td>
</tr>
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<td>Planning error</td>
<td>Implement CPFR model</td>
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<td>Misinformation regarding the availability of bran</td>
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<tr>
<td>8.</td>
<td>Speed of Needs Fulfillment</td>
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<td>Implement CPFR model</td>
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<td>Misinformation regarding the availability of bran</td>
<td>Implement sharing information</td>
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<td>9.</td>
<td>Ability to Provide Raw Materials</td>
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<td>Implement CPFR model</td>
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<td>Implement sharing information</td>
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<tr>
<td>10.</td>
<td>Intensity of Information Exchanges</td>
<td>Rice crop failure</td>
<td>Cooperation with farmer communities</td>
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<tr>
<td></td>
<td></td>
<td>Misinformation regarding the availability of bran</td>
<td>Implement sharing information</td>
</tr>
</tbody>
</table>

#### 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.
(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.

REFERENCES


