Determination of optimum animal feed raw material order allocation

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Abstract. The availability of raw materials is the key to the implementation of production activities so that suppliers, who are able to supply according to the needs of the company, are needed. If the material that comes is not according to the specifications requested, even though the supplier changes so that the amount of material is still fulfilled, it still causes disruption to the smooth production process. The aim of this study is to assess the supplier’s performance to optimize allocated raw material. This research was conducted at an animal feed factory. The raw materials used include yellow corn and rice bran, obtained from several suppliers. The raw material that comes in part is rejected because it is not in accordance with the requested specifications, among others due to excessive water content, mushroom content and the content of corn cobs that exceed the established limit. In this study, carried out a performance analysis of suppliers referring to 23 supplier assessment criteria by Dickson and used 6 selected criteria, namely quality, delivery, history of supplier performance, claim and guarantee policies, prices and communication systems. The optimal amount of raw material orders from the results of goal programming is allocated to each supplier based on their performance.

1. Introduction
Effective supply chain management requires careful consideration of multiple tiers of partners [1]. Necessary capabilities for developing the partners to be able to fulfill their respective purposes needed in the supply chain [2]. Cost-effective material management domain has, therefore, become a competitive priority [3]. Availability of raw materials is important for the sustainability of a company’s production. In order to avoid shortages of raw materials, companies often allocate large amounts of orders, even though storage of materials has a risk of damage or loss, in addition to other risks. The purchasing department of the company is responsible for purchasing raw materials and other needs and the amount can reach 50-80% of the entire company budget [4]. The risk of purchasing materials can be reduced and maximizing the total value of purchases up to 3.9% has been studied in auto-body hydraulic part manufacturers [5-6]. Research on the determination of raw material sources in the supply chain of the cable-making industry can minimize logistics costs and maximize purchase value [7]. The shortage of raw materials from those targeted because they have not considered supplier performance has been studied in the paper recycling industry [8]. Supplier performance evaluation can be used for continuous improvement and performance measurement and can minimize frequent risks...
[9]. A quality factor need to consider such as deterioration of the inherent properties of the materials [10].

This research was conducted at an animal feed company located in North Sumatra. The feed produced includes animal feed for chickens, ducks, pigs and cattle which are produced in the form of mash, pellet or crumble. The types of ingredients used are yellow corn, soy bean meal, corn gluten meal, guar meal, rapeseed meal, and rice bran. Each ingredient was obtained from the same supplier except yellow corn and rice bran from several suppliers. Supplier performance in supplying raw materials has a difference. There are a number of materials that are rejected by the company because they are not according to the specifications specified, as shown in Table 1.

| No | Supplier | Type of Raw Material | Order Amount (ton) | Amount Rejected (ton) |
|----|----------|----------------------|--------------------|----------------------|
| 1. | Supplier A | Yellow corn | 12,883 | 1,461.21 |
| 2. | Supplier B | Yellow corn | 12,285 | 1,630.98 |
| 3. | Supplier C | Yellow corn | 8,571 | 838.40 |
| 4. | Supplier D | Rice bran | 1,359 | 47.72 |
| 5. | Supplier E | Rice bran | 1,465 | 158.21 |
| 6. | Supplier F | Rice bran | 1,181 | 53.77 |

The non-conformity of raw material specifications occurs due to high water content (above 22%), fungus content (aflatoxin) above 50 ppb, or too much corn cob (above 2%). If this happens, the supplier is obliged to replace it, but this results in a disruption to the production floor because the substitute for the raw material comes after the time specified in the order. In this study the performance of each supplier will be assessed and to optimize allocation of raw material purchases based on supplier performance.

2. Method and equipment

Supplier performance appraisal is based on 23 supplier assessment criteria by Dickson. In accordance with the conditions of the company, 6 criteria were selected, namely quality, delivery, claim and guarantee policy, performance history, price, and communication system [11]. Determination of criteria is obtained based on the results of an open questionnaire given to the factory manager, quality control manager and purchasing manager. Likewise, the determination of the sub-criteria. Interrelationships between criteria and sub-criteria [12] are netted through a closed questionnaire, as did the pair-wise comparison questionnaire, which still involved the respondent.

Data processing was carried out using Analytic Network Process [13-14] through the stages of building structured problem models, calculating partial weights and consistency ratios in pair-wise comparison matrices, as well as making super matrix, total weights and determining supplier ratings. To get the optimum amount of order, the Goal Programming [15] and LINDO software methods are used.

3. Results and Discussions

Criteria and sub-criteria obtained based on semi-open questionnaires on the three respondents can be seen in Table 2.
Table 2. Criteria and Sub-Criteria obtained from Questionnaire

| No | Criteria                     | Sub-criteria                                                                 |
|----|-----------------------------|------------------------------------------------------------------------------|
| 1  | Quality                     | K1. Compliance with the desired specifications                               |
|    |                              | K2. Number of raw materials rejected                                         |
|    |                              | K3. Quality consistency                                                      |
| 2  | Shipping                    | P1. Timeliness of delivery                                                   |
|    |                              | P2. Accurate number of shipments                                             |
|    |                              | P3. Flexibility of delivery schedule                                         |
| 3  | Supplier Performance History| KS1. Capability of order fulfillment                                         |
|    |                              | KS2. Ability to maintain good relations                                       |
| 4  | Claim and Guarantee Policies | KKJ1. Willingness to compensate for material                                |
|    |                              | KKJ2. Complaints responsiveness                                              |
|    |                              | KKJ3. Compliance procedures for complaints                                   |
| 5  | Price                       | H1. Low prices                                                               |
|    |                              | H2. Ease of agreement on prices                                              |
|    |                              | H3. Price stability                                                          |
|    |                              | H4. Discount                                                                 |
| 6  | Communication System        | SK1. Easy to contact                                                         |
|    |                              | SK2. Openness in sharing information                                         |

Pair-wise comparisons are carried out between criteria and between sub-criteria in each cluster. In addition, pair-wise comparisons between alternatives (between suppliers) were also carried out for each sub-criteria. After that, a super-matrix calculation is performed. The results of process using Analytic Network Process is obtained for each sub-criteria weights as shown in Table 3.

Table 3. Weight of Sub-criteria

| No  | Criteria                     | Sub Criteria | Normalization Weight | Global Weight |
|-----|------------------------------|--------------|----------------------|---------------|
| 1   | Quality                      | K1           | 0.4276               | 0.28913       |
|     |                              | K2           | 0.4398               | 0.01197       |
|     |                              | K3           | 0.1326               | 0.00361       |
| 2   | Shipping                     | P1           | 0.4197               | 0.36850       |
|     |                              | P2           | 0.2511               | 0.22046       |
|     |                              | P3           | 0.3293               | 0.01163       |
| 3   | Supplier Performance History | KS1          | 0.1027               | 0.00011       |
|     |                              | KS2          | 0.8973               | 0.00095       |
| 4   | Claim and Guarantee Policies | KKJ1         | 0.4194               | 0.01754       |
|     |                              | KKJ2         | 0.3156               | 0.01320       |
|     |                              | KKJ3         | 0.2651               | 0.01109       |
| 5   | Price                        | H1           | 0.6801               | 0.00311       |
|     |                              | H2           | 0.0656               | 0.00030       |
|     |                              | H3           | 0.2063               | 0.00094       |
|     |                              | H4           | 0.0481               | 0.00022       |
| 6   | Communication System         | SK1          | 0.5625               | 0.00005       |
|     |                              | SK2          | 0.4375               | 0.00004       |
|     | **Total**                    |              | **6.0000**           | **1.00000**   |
Ranking of each supplier are shown in Table 4.

Table 4. Ranking of Supplier

| No  | Type of Commodity | Supplier | Total Weight | Rank |
|-----|-------------------|----------|--------------|------|
| 1.  | Yellow Corn       | A        | 0.4053       | 1    |
|     |                   | B        | 0.3944       | 2    |
|     |                   | C        | 0.2004       | 3    |
| 2.  | Rice Bran         | D        | 0.4466       | 1    |
|     |                   | E        | 0.3523       | 2    |
|     |                   | F        | 0.2012       | 3    |

From Table 4 it can be seen that the supplier ranking is obtained based on ANP according to the existing conditions. The company allocates the number of orders to suppliers according to the ranking above. Ranking 1 gets the priority to supply the material, and gets the the biggest order than others for each type of material.

The monthly raw material requirements for yellow corn and rice bran are shown in Figure 1 and the minimum and maximum order data from each supplier are listed in Table 5.

Figure 1. Required Raw Material

Table 5. Minimum and Maximum Order

| No  | Raw Material  | Supplier | Minimum Order (tons) | Maximum order (tons) | Price/ton (Rp.000) |
|-----|---------------|----------|----------------------|----------------------|-------------------|
| 1.  | Yellow Corn   | A        | 500                  | 3,000                | 3,400             |
|     |               | B        | 200                  | 3,000                | 3,300             |
|     |               | C        | 100                  | 2,000                | 3,100             |
| 2.  | Rice Bran     | D        | 5                    | 500                  | 2,500             |
|     |               | E        | 10                   | 500                  | 2,600             |
|     |               | F        | 5                    | 200                  | 2,550             |
Not all materials ordered come according to the specifications requested. The number of out of specification corn ranges from 1.17% to 1.47%, while rice bran ranges from 0.4 to 0.9%. The calculation of the number of raw material orders from each supplier is done by the goal programming method with the help of LINDO software and the results can be seen in Table 6.

Table 6. Results of the 13th to 18th Month Order Allocation

| Raw Materials | Supplier | Allocation results with goal programming (tons) | Total |
|---------------|----------|-----------------------------------------------|-------|
|               |          | Month 13 | Month 14 | Month 15 | Month 16 | Month 17 | Month 18 |
| Yellow Corn   | A        | 2,762    | 500      | 2,008    | 2,375    | 780      | 1,960     | 10.385   |
|               | B        | 200      | 1,024    | 700      | 200      | 500      | 200       | 2.824    |
|               | C        | 100      | 1,827    | 300      | 100      | 300      | 100       | 2.727    |
|               | TOTAL    | 3,062    | 3,350    | 3,008    | 2,675    | 1,580    | 2,260     | 15,935   |
| Rice Bran     | D        | 162      | 148      | 472      | 500      | 300      | 500       | 2.082    |
|               | E        | 10       | 10       | 10       | 10       | 50       | 10        | 100      |
|               | F        | 5        | 5        | 5        | 90       | 0        | 15        | 120      |
|               | TOTAL    | 177      | 163      | 487      | 600      | 350      | 525       | 2,302    |

From Table 6 above, it can be seen that Supplier A receives the largest order allocation, namely 65% of the total raw material requirement for yellow corn and supplier D is requested to fulfill 90% of the raw material requirements for rice bran. From the table, it is clear that the highest priority is given to the best ranking.

Supplier performance assessment needs to be done so that the supplier knows the extent of its performance so far. Consequently, suppliers with high performance will get larger orders compared to suppliers with low performance. This will encourage suppliers to continue to improve their performance.

Supplier performance evaluation conducted by Hawkins et al shows a number of weaknesses related to information on supplier performance, identification of risks and factors that affect risk mitigation effectiveness [16]. Supplier empowerment has been studied by Liao et al, covering cognitive concept in mediating relationship between suppliers' process and mutual trust with customers and suppliers' services performance operations and customer services [17]. The purchasing department at the company needs to monitor supplier performance. The Supplier Development Program was reviewed by Bentor Jr. et al cover a number of programs and the results show that operational procedures affect the buying and selling relationship in the organization. Communication, cooperation, and commitment are key to supplier performance [18].

4. Conclusions
Supplier performance assessment criteria used in this study are (1) Quality, (2) delivery, (3) supplier performance history, (4) claim and guarantee policies, (5) prices and (6) communication systems. The optimum amount of order allocation is divided into each supplier according to their performance.

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