Calculation of optimal raw material purchase costs using normalized goal programming method

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Abstract. Supplier selection is a very important activity to build an effective supply chain. The purchasing department is the department responsible for determining the number of raw material purchases from several suppliers. The purchase of optimal raw materials is done using normalized goal programming. Supplier selection criteria serve as targets to minimize the cost of purchasing raw materials, minimize reject of raw materials, and minimize delays in raw materials. From the results of the study obtained an optimal allocation of raw material orders and calculated the optimal cost of purchasing raw materials. Finally, order allocation by selecting the right supplier can reduce purchasing costs by 6.51% rice bran raw material, 4.85% yellow corn raw material, and 4.71% shrimp head flour raw material.

1. Introduction
Competition in the tight business requires the company to take advantage of every opportunity to optimize every activity carried out. A company must work with supply chain partners to improve total chain performance to remain competitive [1]. Products with low cost and high quality cannot be produced without the support of reliable suppliers. Selection of the right supplier can give the company a competitive advantage that plays a role in reducing costs and improving product quality [2]. Allocating orders of raw material to the right supplier can minimize the cost of purchasing raw materials. Cooperation with suppliers can improve supply chain performance more competitively. The selection of suppliers with poor performance can make delays in the arrival of raw materials, failure in meeting the needs of raw materials. If the fulfillment of raw materials cannot be fulfilled as it is due to the improper allocation of orders to suppliers, it will hamper the production process and have a negative impact on supply chain performance.

Agribusiness companies that produce fish feed collaborate with various suppliers to purchase raw materials. The purchase of raw materials has so far been based on subjective prices and quality of raw materials. However, each supplier has different performance, especially in terms of price, quality, and on-time delivery. The selection of suppliers who have poor performance can harm the company in terms of the cost of purchasing raw materials. Losses caused by the quality and number of raw material orders have not met the expected criteria. For this reason, supplier selection is based on supplier performance to reduce the cost of purchasing raw materials.

Minimizing the cost of purchasing raw materials can be done by using several methods, one of them is the normalized goal programming method. Goal programming (GP) is used widely for solving multi-criteria decision making (MCDM) and multi-objective decision making (MODM) problems because of its simplicity and flexibility. Goal programming can handle relatively large numbers of decision variables, resource constraints, and objectives [3][ 4]. Goal programming is a branch of multi-objective optimization; it extends linear programming to deal with multiple, normally conflicting objectives [3][ 5][ 6]. Development of fuzzy goal programming to determine suppliers with more than one objective function (multi-objective fuzzy) [7]. Supplier selection criteria are very important to be considered by decision-makers in selecting the best supplier [8]. Weighted goal programming (WGP) can also be used
to solve problems in selecting suppliers with the goal of more than one criterion, in accordance with specified criteria and limits. Normalized goal programming can produce objectives consistently with the goals of its function [9].

For example, the application of multi-objective dynamic value functions in the allocation of orders based on supplier performance selection results in a total cost purchase increase of 7% of the ideal minimum total cost purchase and a total value purchase decrease of 20% of the ideal maximum total value purchase. However, if minimization is only done on the total cost purchase (the number of orders obtained for the minimum total cost of purchase), then the total value purchase can decrease by 26% compared to the ideal value [2]. Research on a multi-objective approach to supplier selection aims to improve quality, reduce purchasing costs and maximize timely delivery. This approach was successfully carried out using fuzzy methods, min-max models and linear programming. The results of the study resulted in the attainment of a minimum that was acceptable for the first goal and for a level of demand greater than 0.75 as the wishes of the decision-maker. The solution obtained is the minimum level of achievement 0.687 greater than the minimum level of achievement of the fuzzy model solution (0.611) [10].

Based on previous research, it is known that the application of Normalized goal programming can provide a solution for decision-makers in determining suppliers with more than one objective goal. This research was conducted to minimize the cost of purchasing raw materials by selecting suppliers that have more than one predetermined objective criteria.

2. Methodology
This research was conducted in Medan City Company engaged in agribusiness that produces fish feed. The object under study is the cost of purchasing raw materials at the company. The research began by making direct observations on the company's purchasing department. Activities undertaken are observing the situation that is happening in the purchasing department. Then the research topics and objectives are determined in accordance with the conditions of the department. Then, data collection is needed to minimize purchasing costs at the department. Data collected in the form of forecast data the number of product requests and supplier performance data. Based on these data, a Positive Ideal Solution (PIS) and Negative Ideal Solution (NIS) formulation were performed. PIS and NIS are objective functions that can be calculated using linear programming with the goal of minimization (PIS) and maximization (NIS). Next, a Normalized Goal Programming (NGP) formulation was carried out which seemed to be the development of Weighted Goal Programming (WGP). WGP requires decision-makers to determine the value or goal for each object that serves to minimize the goal deviation. The normalization approach to goal programming is by setting proportional object objectives whose weights are determined by the decision-maker. The normalization approach cannot guarantee that objective objectives can be consistent with the goals or goals achieved [11]. NGP uses the PIS and NIS variables as target function variables for the purchase of raw materials. Normalization approach with Deterministic Goal Programming, where the level of objective function value is determined by the decision-maker. Then as much as possible objective objectives can be consistent with the specified value level [9].

3. Result and discussion
This research was conducted by collecting the required data in the form of forecast data on the number of product requests and supplier performance data. Data forecasts the number of product requests forecasting product demand for one year in 2017 based on the number of product requests in 2013-2016. Supplier performance data includes the number of raw material orders, the price of raw materials, the maximum supply capacity of suppliers, the number of raw materials reject, reject rate, many days of delay and the level of delay of each supplier.
3.1. Calculation of optimal raw material purchase costs

Normalized Goal Programming Model with supplier selection and allocation order serves to get the optimal number of raw material orders. After obtaining an optimal number of raw material orders, then the optimal raw material purchase costs can be calculated. The optimal raw material purchasing costs for rice bran raw materials are shown in Table 1.

| Raw Material      | Actual Purchase Costs (IDR) | Purchase Costs Based on NGP (IDR) | Cost reduction (IDR) |
|-------------------|-----------------------------|----------------------------------|----------------------|
| Rice Bran (IDR)   | 877,215,000                 | 820,132,800                      | 57,082,200           |
| Yellow Corn (IDR) | 1,391,814,400               | 1,324,294,100                    | 67,520,300           |
| Shrimp Head Flour (IDR) | 745,666,800              | 710,520,200                      | 35,145,600           |
| Total             | 3,104,696,200               | 2,854,947,100                    | 159,749,100          |

Based on the table above the reduction in costs incurred if the allocation of raw material orders is determined by the Normalized Goal Programming for the period of January - March 2017, namely rice bran raw material by IDR 57,082,200 (6.51%), yellow corn raw material as much as IDR 67,520,300 (4.85%), and shrimp head flour as raw material for IDR 35,145,600 (4.71%).

The allocation of raw material orders to the right suppliers will reduce the risk of purchases such as the low quality of raw materials, delays in delivery and other matters which will certainly hamper the smooth production process. It has a positive impact on improving overall company performance.

4. Conclusion

Based on the use of Normalized Goal Programming, the cost of purchasing raw materials has decreased the purchase costs for the period of January - March 2017 by IDR 57,082,200 for rice bran raw material, IDR 67,520,300 for raw materials for yellow corn, and a reduction in the cost of purchasing raw materials for shrimp head flour by IDR 35,146,600. With a total reduction in the cost of purchasing raw materials IDR 159,749,100 (5.15%). Normalized Goal Programming can determine the best supplier based on supplier performance data. The allocation of raw material purchase orders to the right supplier can reduce the reject of raw material purchases and delay in the arrival of raw materials. The results of this study indicate that the application of Normalized Goal Programming can allocate orders to existing supplier choices effectively. So as to reduce the cost of purchasing raw materials optimally.

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