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Optimization of Raw Material Order Quantity for Single Items Multiple Suppliers Using Linear Programming Methods: A Case Study at PT. TELPP

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Abstract. PT. Tanjungenim Lestari Pulp and Paper (TLPP) is a world-class pulp manufacturer with high-quality products and environmentally friendly pulp mills. The company uses Eucalyptus Pellita trees as raw material, which will be processed into paper pulp. The problem currently faced by the company is a shortage of raw materials (under stock), which means that when the company experiences a shortage of raw materials, it will not be able to meet its monthly and daily production targets. This study aims to determine the optimal order quantity from two suppliers while minimizing total costs at TLPP using the Linear Programming approach. The results of the study indicate the optimal order quantities for both suppliers. Thus, this method can be applied by the company to avoid lost sales that could be detrimental to the company.

Keywords: Linear Programming, Inventory, Shortages and Surpluses of Raw Materials, Economic Order Quantity

1. Introduction

The manufacturing industry is one of the industrial sectors that produces raw materials into finished goods, thereby adding value and marketability for distribution. The manufacturing industry has a complex system for producing goods, one of the most important systems being the control of raw material inventory, which affects a company's production targets. Raw materials are a top priority for companies in order to maintain a smooth production process. Therefore, controlling raw material inventory is a very important issue so that companies do not experience a shortage of raw materials or an excess of raw materials stored in warehouses.

PT. Tanjungenim Lestari Pulp and Paper using raw materials from Eucalyptus Pellita trees, which will be processed into paper pulp. The company's products are then exported to other companies to be reprocessed into products made from paper pulp. The company's daily production target is 1,400 tons on working days and 1,500 tons on holidays. Therefore, the company targets a monthly production of 44,000 tons of pulp.

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Companies often fail to meet their monthly production targets due to a lack of raw materials, as was the case in the last three months of 2024, when the average production target was 45,000 tons/month but the company was only able to produce an average of 39,000 tons/month. This was because suppliers were only able to deliver 6,000 tons of peeled wood per day.

Companies often fail to meet their monthly production targets due to a lack of raw materials. The problem currently faced by companies is a shortage of raw materials (under stock), which means that when a company experiences a shortage of raw materials, it will not be able to meet its monthly or daily production targets. With this problem, companies need to add new suppliers in order to meet their production targets. On the other hand, with the addition of suppliers, companies must consider how to determine the optimal order quantity for each supplier while taking into account the minimum total cost. In the case of supply change management, this case can be categorized into a single item multi supplier model.

Much research has been conducted on the multi-item single supplier model, or multi-item multi-supplier model. Some studies related to the single item multi-suppliers model are still limited, including research that discusses the optimization model for raw material procurement for one type of item ordered from several suppliers (multi-suppliers) by considering variations in lead time, price-quantity discount policies, and resource constraints such as warehouse capacity and budget [2]. Another study is an integrated production-inventory model with multi-item is developed from the perspectives of a single producer, multiple suppliers and retailers. In this three-layer supply chain, the retailers are non-competing. Each supplier delivers only a single type of raw material to the producer [3]. Meanwhile, this study will use an optimization method to solve the problem of the single item multi-supplier model, by considering the supplier's capacity to meet production needs, with the criterion of minimizing inventory costs.

2. METODHOLOGY

This subchapter will discuss the problem-solving process in the context mentioned above.

2.1. Calculation of Raw Material Requirements

The calculation of raw material requirements involves converting production target data into raw material requirement data for the company for a period of 6 months. The purpose of this calculation is to determine the raw materials that will be used and ordered from both suppliers over a period of 6 months.

2.2. Calculation of Ordering Costs and Holding Costs

This study calculates ordering costs, which consist of administrative costs, system integration costs, telecommunications costs, and transportation costs. Each supplier has different ordering costs, so it is necessary to calculate the ordering costs for both suppliers. Holding costs consist of warehouse costs, maintenance costs, and investment rates. In this company, there are no warehouse and maintenance costs because it uses an open field and does not require special maintenance for the raw materials ordered. Therefore, the

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investment rate is used to calculate storage costs. Storage costs can be calculated by multiplying the Bank Indonesia interest rate (BI rate) by the price of raw materials.

2.3. Formulation of Problem Solving

Linear programming is a mathematical technique designed to assist managers in planning and decision making. This technique is used to optimally allocate limited resources to achieve specific goals, such as maximizing profits or minimizing costs [4].
Linear programming has three main components in solving complex problems [4].

1. *Objective Function*
   The objective function is a function that describes the objectives/goals of a linear programming problem related to the optimal allocation of resources to achieve optimal results.
2. *Constraint Function*
   The constraint function is a mathematical representation of the available capacity limitations that will be optimally allocated to various activities.
3. *Decision Variables*
   Decision variables are aspects of the model that can be controlled. The values of decision variables are possible alternatives of linear functions.

The basic assumptions used in analytical models are Linear programming is as follows [1]:

1. Proportionality
2. Additivity
3. Determinism
4. Accountability

In this study, the characteristics used in this problem are as follows:

1. Objective Function: Minimization of total inventory costs when ordering raw materials from two suppliers.
2. Decision Variables: The optimal order quantity for supplier 1 and supplier 2.
3. Constraints: The constraints in this problem are the maximum order quantity for both suppliers and the sum of the optimal order quantities for the two suppliers must be greater than 0.

These characteristics are used to determine the formulation used to solve the problem in the company. The formulation used in this problem is:
Decision Variables:
q_1 = Number of Orders at Supplier 1
q_2 = Number of Orders at Supplier 2
Purpose Function:

$$minO_T = \left((P_1 \times D_1) + \left(\frac{A_1 D}{q_1}\right) + \left(\frac{1}{2} h_1 q_1\right)\right) + \left((P_2 \times D_2) + \left(\frac{A_2 D}{q_2}\right) + \left(\frac{1}{2} h_2 q_2\right)\right) \quad (1)$$

Limitations:
$q_1 > q_2$
$q_1 \leq MaksOrderS1$
$q_2 \leq MaksOrderS2$

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$(q_1 + q_2) \times f = D$

$q_1 \geq 0$

$q_2 \geq 0$

Where:

O_T = Total Cost

P_i = Price of Raw Materials from Supplier-i

A_i = Order Cost from Supplier-i

D = Production Target

h_i = Storage Cost from Supplier-i

q_i = Order Quantity from Supplier-i

$i = 1, 2$

2.4. Calculation of Optimal Raw Material Order Size

In this study, the optimal raw material order size is calculated by optimization of Economic Order Quantity (EOQ) and linear programming. Economic Order Quantity (EOQ) is an inventory control technique that minimizes the total costs of ordering and storage [5]. In this study, the calculation of the optimal raw material order size was assisted using the MathCAD application with equation (1) and existing constraints, taking into account the minimum inventory cost.

3. Result And Discussion

The following are the results of data processing and analysis conducted on problem solving in the company.

3.1. Data Collection

A. Production Target Data

Production target data to be carried out by the company for the period July to December 2025. The company's production target data can be seen in Table 1.

Table 1 Production Target Data

Month	Production Target (Tons)
July	44200
Agust	44400
September	44300
October	44200
November	43000
December	40000
Total	260100

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B. Raw Material Requirements Data

Raw material requirements can be calculated from production target data with a conversion of 1000 tons of production target requiring 6000 tons of primary raw materials. Raw material requirements data can be seen in Table 2.

Table 2 Raw Material Requirements Data

Month	Raw Material Requirements (Tons)
July 25	265200
Agust 25	266400
September 25	265800
October 25	265200
November 25	258000
December 25	240000
Total	1560600

C. Ordering Costs

Orders were placed with the first supplier, which had been supplying raw materials to the company. However, due to the increase in demand for raw materials, the first supplier was unable to meet the company's demand, so the company had to add another supplier in order to meet its raw material requirements. The ordering costs obtained from the two suppliers are shown in Table 3.

Table 3 Ordering Costs

Supplier	Biaya (Rp)				Total
	Administration	Integration/ system	Telecommunications	Transportation	
Supplier 1	Rp75.000,00	Rp25.000,00	Rp25.000,00	Rp250.000,00	Rp375.000,00
Supplier 2	Rp60.000,00	Rp25.000,00	Rp25.000,00	Rp220.000,00	Rp330.000,00

D. Storage Cost Data

Storage costs can be calculated by multiplying the Bank Indonesia interest rate (BI rate) by the price of raw materials. Storage cost data can be seen in Table 4.

Table 4 Storage Cost Data

Type	Price	Interest Rate	Total Savings Cost
Supplier 1	Rp. 1.200.000,00	2,75%	Rp. 33.000,00
Supplier 2	Rp. 1.500.000,00		Rp. 41.250,00

E. Raw Material Price Data

This raw material data is used for data processing in this study. Raw material data for both suppliers can be seen in Table 5.

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Table 5 Raw Material Price Data

Supplier	Raw Material Price (Rp/Ton)
Supplier 1	Rp 1.200.000,00
Supplier 2	Rp 1.500.000,00

3.2. Calculation of Optimal Raw Material Order Size

The determination of the optimal order quantity and minimum total cost was performed using Linear Programming with the Math-CAD application, which uses the written objective function and specified constraints. The calculation results from the Math-CAD application can be seen in Figure 1.

Fig. 1 Calculation of Optimal Raw Material Order Size

Based on the above calculations, the optimal order quantity for supplier 1 is 5,995 tons and for supplier 2 is 4,996 tons, with a total cost of Rp. 402.656.620,309

3.3. Linear Programming Calculation Analysis with Lost Sales Conditions

A company with 1 supplier experiences lost sales, which causes losses to the company. These losses were due to lost sales of about 26.424 tons (26,424 kg) with the selling price of the product per kg being Rp. 43,200 so the total lost sale is around Rp 1.141.500.000,00. The results of the calculation using Linear Programming with the Math-CAD application provide the optimal order size for both suppliers, taking into account the limitations

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between suppliers. Based on the calculation results using the Math-CAD application, the optimal order quantity for supplier 1 is 5,955 tons per order, and the optimal order quantity for supplier 2 is 4,996 tons per order. for a total order of 848,592 tons in 6 months with an order frequency of 142 times for supplier 1 and 712,008 tons in 6 months with the same order frequency for supplier 2. The order value is obtained from the minimum total cost for 6 months, which is IDR 2,488,979,020,309.00. With this plan, the company can reduce production costs by 20% and maximize profits without losing sales.

3.4. Analysis of Raw Material Storage Space Availability

In this study, the company has 11 log yards used to store raw materials delivered by suppliers in the form of open fields with an area of 50m × 50m per log yard. With this warehouse area, the company can properly store raw materials delivered by supplier 1 and supplier 2. The results of the current raw material ordering plan minimize raw material storage in the warehouse, so that only a small amount of raw materials are stored. In addition, this calculation can optimize the storage costs incurred by the company, as there is no longer a need for maintenance costs to be incurred by the company.

Conclusion

Based on the results and analysis that have been carried out, the conclusions that The Linear Programming model calculation obtained optimal order results for supplier 1 of 5,955 tons in 6 months with an order frequency of 142 times (almost every day) and for supplier 2 of 4,996 tons with an order frequency of 142 times (almost every day). The total inventory costs incurred by the company over 6 months amounted to IDR 2,488,979,020,309.00. Compared to using 1 supplier that has higher costs, this method can reduce costs by 20%. Therefore, this method can be applied by companies to avoid lost sales that can harm the company. This calculation takes into account the company's purchasing costs, ordering costs, and storage costs.

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