Optimization of Furniture Raw Material Inventory Using the EOQ-Lagrange Multiplier Method

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Abstract
PT XYZ is a furniture company specializing in products made from wood and rattan. PT XYZ has sub-optimal problems in controlling raw material inventories, resulting in inventory cost overruns and warehouse overcapacity. This research aims to determine the optimization of the raw material in the inventory according to the available warehouse capacity using the Economic order quantity-Lagrange Multiplier method. From the research results, it was found that the total warehouse using the Lagrange Multiplier method was 107,922 m³, which shows that this value is optimal because it does not exceed the capacity of the warehouse owned by PT XYZ, which is 108 m³. By applying the Lagrange Multiplier method, it is possible to save total inventory costs of IDR 17,219,173 or 6.36% of the company’s total inventory costs, with an order size of 37 m³ for mindi wood and 26 m³ for mahogany wood.

Keywords
Lagrange Multiplier, EOQ, Inventory, Forecasting
A. Introduction

Industry in the world has grown and developed rapidly along with its development, and competition between companies will become increasingly fierce, especially in various fields in various industries [1]. Companies must be able to develop strategies to survive, namely effective means of fulfilling consumer desires, which can be realized by establishing inventory control [2]. Good inventory management will ensure a production system runs smoothly and vice versa [3]. Inventory is the need for goods, including raw materials, semi-finished goods, and finished goods, which will be arranged and processed by the company according to needs to meet production needs well in stable and fluctuating market conditions [4]. Even though inventory is important, many companies compete to minimize or eliminate their inventory. This is because the costs incurred for inventory do not directly provide added value to the product [5].

Even though inventory does not add value to a product, it has a function. Inventory has an important function, such as balancing consumer demand with raw material supplies and the time required to procure supplies [6]. Having an inventory will avoid erratic price changes in the market and shortages of raw material stock and maintain a smooth production process so that it is not hampered [7]. Every company wants to procure the right inventory, so there is no increase in inventory costs, likewise. PT XYZ is a company that specializes in products made from wood and rattan, which are included in the furniture company. Of course, the manufacturing industry has problems. PT XYZ has recently experienced problems in the inventory sector. PT XYZ often buys excess raw materials from mahogany and mindi wood. Mahogany wood and mindi wood are the most widely used raw materials because of their affordable prices and lightweight nature, which will reduce shipping costs.

Excessive purchasing of raw materials will cause many problems if not resolved immediately. Based on data from the company, wood purchases and usage for one year, namely February 2023 to January 2024, resulted in Mindi wood purchases amounting to 1160,931 m³, with a total usage of 1123,596 m³, or 96.78% of the total wood purchases, leaving 37,335 m³. Meanwhile, mahogany wood purchases for one year, namely February 2023 to January 2024, amounted to 472,787 m³, and wood usage amounted to 445,043 m³, or around 94.1319% of the total wood purchases, leaving 27,744 m³. PT XYZ also has limitations in its warehouses. PT XYZ’s warehouse for storing mindi wood and mahogany wood measures 60 m² with a length of 10 meters and a width of 6 meters. This excess stock occurs at the end of each period, and the overstock condition always exceeds the existing warehouse capacity. This excess stock occurs at the end of each period, and this condition always exceeds the existing warehouse capacity. When there is excess stock, it will also affect the costs borne by storage. When the warehouse is full, the wood will be placed outside the warehouse, reducing the quality of the wood. Given this, it is necessary to plan optimal raw material supplies using the Lagrange Multiplier method.

The Economic Order Quantity (EOQ) with Lagrange method is highly suitable for application in cases where there are constraints in inventory management [8]. The Lagrange method itself has been widely applied to various planning-related
problems with constraints, including material planning with capacity constraints [9], [10], [11] and supply chain planning with cost and capacity constraints [12]. Therefore, this research proposes controlling inventory using warehouse capacity using the Lagrange Multiplier method at PT XYZ.

B. Research Method

1) Identification and Operational Definition of Variables

a. Dependent variable
The dependent variable is a result of the existence of the independent variable. Included in the dependent variable in this research is the optimal supply of raw materials at PT XYZ.

b. Independent Variable
Independent variables include influence variables, where this variable exists and will change other variables. The independent variables in this research are:
   2. Ending Inventory.
   3. Inventory Costs (Order Costs and Holding Costs).
   7. Lead Time Data.
   8. Order Size.

2) Problem Solving Steps

a. Variable Identification
Identify variables to find out what variables influence and are related to solving problems using the Lagrange Multiplier method.

b. Data collection
In the data collection process, researchers collect the data and information needed from the company to solve the problem being studied.

c. Calculation of Warehouse Capacity using the Company Method
At this stage, warehouse capacity is calculated using the company method. This is to determine whether the storage space has excess capacity.

d. Total Cost with Company Method (TCp)
After calculating the warehouse capacity using the company method, total costs (holding costs and ordering costs) are also calculated based on the warehouse capacity using the company method.

e. Calculation of Inventory Without Constraints Using the EOQ (Q*) Method
Calculate inventory without constraints using the EOQ method based on demand data, order cost data, and purchase price data to calculate the order size [13].
f. Calculate the Total Warehouse Space with EOQ.

Calculate total warehouse space based on order size and calculation (Qi*) using EOQ so that it can be seen in the latest capacity figures [14].

g. Calculations with Inventory Capacity Constraints using the Lagrange Multiplier Method

Calculating inventory with constraints using the Lagrange multiplier method (Q_Li*). After calculating the latest capacity with EOQ, calculate inventory with constraints using the proposed method. The number of orders can be found based on existing storage data, the latest total capacity using EOQ, and Qi* calculations using the EOQ method.

h. Calculation of Total New Storage Space using the Lagrange Multiplier Method.

Based on warehouse capacity data and calculations (Q_Li*) using the Lagrange Multiplier method, the total capacity of the new warehouse is calculated.

i. Calculation of Total Cost using the Lagrange Multiplier Method (TC Q_Li*)

j. Comparison of Real Company Data with the Lagrange Multiplier Method.

In this section, two conditions will be compared, namely looking at the condition of the company with the proposed method, namely the Lagrange Multiplier method. If the total cost of the company method is greater than the total cost of the Lagrange multiplier method, then there will be efficiency, and you can continue with the next process, namely plotting the data [15].

k. Forecasting

Data plotting is the first step in forecasting calculations to determine what data patterns are studied to form data patterns. The data used is raw material purchase data from February 2023 to January 2024. After knowing the data pattern, the next step is to determine a forecasting method that matches the data pattern. Data calculations use a predetermined forecasting method that matches the data pattern. Next, an error test calculation will be carried out. The results of the smallest error test reflect a more accurate forecast because the error rate is small. At this stage, forecasting verification will be carried out, resulting from forecasting data from future purchases of furniture raw materials (mahogany and mindi wood), which are by the data obtained and will be used to determine purchase calculations in inventory control.

l. Results and Discussion

The results of all calculations are then analyzed and discussed to find out the final results of solving the problem using the Lagrange Multiplier method.

3) Data Collection Methods

a. Primary Data
This data is data collected by researchers directly in the field. Primary data in this research was obtained through interviews, observation and documentation.

b. Secondary Data

Secondary data is data that comes from indirect sources or from the results of previous research that is related to the object being studied. Secondary data can be obtained by taking data from books, literature, or documents from the company, as well as other information related to the object under study.

C. Result and Discussion

1) Data Collection

Data on Furniture Raw Material Requirements can be seen in Table 1.

<table>
<thead>
<tr>
<th>No.</th>
<th>Month</th>
<th>Mindi Wood (m³)</th>
<th>Mahogany Wood (m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>February 2023</td>
<td>90.201</td>
<td>38.0656</td>
</tr>
<tr>
<td>2</td>
<td>March 2023</td>
<td>100.189</td>
<td>42.6054</td>
</tr>
<tr>
<td>3</td>
<td>April 2023</td>
<td>92.268</td>
<td>37.5747</td>
</tr>
<tr>
<td>4</td>
<td>May 2023</td>
<td>91.628</td>
<td>40.9817</td>
</tr>
<tr>
<td>5</td>
<td>June 2023</td>
<td>92.406</td>
<td>37.9435</td>
</tr>
<tr>
<td>6</td>
<td>July 2023</td>
<td>94.995</td>
<td>39.3949</td>
</tr>
<tr>
<td>7</td>
<td>August 2023</td>
<td>101.113</td>
<td>37.3104</td>
</tr>
<tr>
<td>8</td>
<td>September 2023</td>
<td>91.673</td>
<td>38.4069</td>
</tr>
<tr>
<td>9</td>
<td>October 2023</td>
<td>101.737</td>
<td>40.501</td>
</tr>
<tr>
<td>10</td>
<td>November 2023</td>
<td>91.914</td>
<td>38.4242</td>
</tr>
<tr>
<td>11</td>
<td>December 2023</td>
<td>102.047</td>
<td>39.4641</td>
</tr>
<tr>
<td>12</td>
<td>January 2024</td>
<td>110.761</td>
<td>42.1147</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>1160.931</td>
<td>472,787</td>
</tr>
</tbody>
</table>

Final Inventory data can be seen in Table 2.

<table>
<thead>
<tr>
<th>No.</th>
<th>Wood Materials</th>
<th>Ending Inventory (m³)</th>
<th>Purchase Cost (m³)</th>
<th>Final Product Residual Value (IDR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mindi Wood</td>
<td>58</td>
<td>IDR 2,806,504</td>
<td>IDR 162,777,232</td>
</tr>
<tr>
<td>2</td>
<td>Mahogany Wood</td>
<td>25</td>
<td>IDR 2,253,690</td>
<td>IDR 56,342,250</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td></td>
<td>IDR 219,119,482</td>
</tr>
</tbody>
</table>

Inventory Costs can be seen in Table 3.

<table>
<thead>
<tr>
<th>No.</th>
<th>Type of Fee</th>
<th>Overall Cost</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ordering Cost</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a. Telephone Fee</td>
<td>IDR 200,000</td>
<td>Per Month</td>
</tr>
<tr>
<td></td>
<td>b. Administration fee</td>
<td>IDR 500,000</td>
<td>Per Month</td>
</tr>
<tr>
<td></td>
<td>c. Labour costs</td>
<td>IDR 4300,000</td>
<td>Per Month</td>
</tr>
<tr>
<td></td>
<td>Total Order Cost</td>
<td>IDR 5,000,000</td>
<td>Per Month</td>
</tr>
<tr>
<td>2</td>
<td>Holding Cost</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Raw Material Storage Cost</td>
<td>5 %</td>
<td>Per Year</td>
</tr>
<tr>
<td></td>
<td>Risk of damage</td>
<td>2 %</td>
<td>Per Year</td>
</tr>
<tr>
<td></td>
<td>Total Holding Costs</td>
<td>7 %</td>
<td>Per Year</td>
</tr>
</tbody>
</table>
Unit price for the products can be seen below.

<table>
<thead>
<tr>
<th>Table 4. Price of Each Wood Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
</tr>
<tr>
<td>-----</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
</tbody>
</table>

The warehouse is a temporary place to store raw materials before they enter the production section. However, warehouses certainly have limitations in accommodating these raw materials. PT XYZ has a warehouse for storing mindi and mahogany wood with an area of 60 m$^2$, which has a length of 10 meters and a width of 6 meters with a stacked wood pile height of 3 meters, resulting in a warehouse space volume of 180 m$^3$. Of the volume of warehouse space, 40% is used as an access road for laying wood, namely by using a forklift, so that the warehouse capacity for mindi wood and mahogany wood can accommodate around 108 m$^3$ of wood.

<table>
<thead>
<tr>
<th>Table 5. Data on Wood Material Storage Media, Capacity, and Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
</tr>
<tr>
<td>-----</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
</tbody>
</table>

Safety Stock of Mindi Wood and Mahogany Wood can be seen below.

<table>
<thead>
<tr>
<th>Table 6. Safety Stock</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
</tr>
<tr>
<td>------</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
</tbody>
</table>

Lead Time Data can be seen below.

<table>
<thead>
<tr>
<th>Table 7. Lead Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
</tr>
<tr>
<td>--------</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
</tbody>
</table>

Order Size can be seen below.

<table>
<thead>
<tr>
<th>Table 8. Order Size of Each Wood Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
</tr>
<tr>
<td>-----</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
</tbody>
</table>

2) Data Processing
A. Inventory Control Using Company Methods
Based on warehouse capacity data and order size data, the total warehouse inventory calculation is calculated using the following formula:

\[
\text{Total storage warehouse} = \sum_{i=1}^{n} w_i Q_i \leq W
\]  

(1)

\[
7.88 \times \frac{30}{4.6} + 7.88 \times \frac{35}{4.6} \leq 108 \text{ m}^3
\]

\[
51,391 \text{ m}^3 + 59,957 \text{ m}^3 \leq 108 \text{ m}^3
\]

\[
111,348 \text{ m}^3 \leq 108 \text{ m}^3
\]

Based on the calculation above, the capacity obtained from the company method is 111,348 m³, and this value is not optimal because it exceeds the existing capacity of PT XYZ, which is 108 m³.

Calculation of Total Cost Company Method can be seen below.

a) Ordering Cost

Mindi Wood

Order Frequency = \left( \frac{\text{Total Mindi Wood Needs per Year}}{\text{Order Size}} \right)

= \left( \frac{1160,931}{30} \right)

= 38,698 \approx 39 \text{ times}

Ordering Cost = Order Frequency \times \text{Order Cost}

= 39 \times \text{IDR 5.000.000}

= \text{IDR 195.000.000}

Mahogany Wood

Order Frequency = \left( \frac{472.782}{35} \right)

= 13,508 \approx 14 \text{ times}

Ordering Cost = 14 \times \text{IDR 5.000.000}

= \text{IDR 70.000.000}

b) Holding Cost

Mindi Wood

= \left( \frac{Q}{2} \right) \times (\alpha \times \text{Purchase Price})

= \left( \frac{30}{2} \right) \times (7\% \times \text{IDR 2.806.504})

= \text{IDR 2.946.829}

Mahogany Wood

= \left( \frac{35}{2} \right) \times (7\% \times \text{IDR 2.253.690})

= \text{IDR 2.760.770}

c) Total Cost Company Method (TC_p)

\[
TC_p = \text{Ordering Cost} + \text{Holding Cost}
\]

= \text{IDR 195.000.000} + \text{IDR 70.000.000} + \text{IDR 2.946.829} + \text{IDR 2.760.770}

= \text{IDR 270.707.599}
B. Inventory Control using the Lagrange Multiplier Method

The EOQ \((Q^*_i)\) calculation will be calculated based on data on wood material requirements, inventory cost data, and purchase price data so that the order quantity can be calculated using the following formula:

\[
Q^*_i = \sqrt{\frac{2 \times D_i \times A_i}{a \times C_i}} \quad (7)
\]

a) Mindi Wood \(= \sqrt{\frac{2 \times 1160.931 \times IDR \ 5.000.000}{0.07 \times IDR \ 2.806.504}} = 243 \text{ m}^3\)

b) Mahogany Wood \(= \sqrt{\frac{2 \times 472.787 \times IDR \ 5.000.000}{0.07 \times IDR \ 2.253.690}} = 173 \text{ m}^3\)

Based on existing warehouse capacity data and calculations using the EOQ \((Q^*_i)\) method, the total new storage space is calculated using the Economic Order Quantity (EOQ) method with:

\[
\sum_{i=1}^{n} w_i Q^*_i \leq W \quad (8)
\]

\[
7.88 \times \frac{243}{4,6} + 7.88 \times \frac{173}{4,6} \leq 108 \text{ m}^3
\]

\[
416,270 \text{ m}^3 + 296,357 \text{ m}^3 \leq 108 \text{ m}^3
\]

\[
712,626 \text{ m}^3 \leq 108 \text{ m}^3
\]

Based on the calculations above, the total new storage (warehouse) space is 712,626 m\(^3\). These results are still not optimal because the order placed exceeds the warehouse capacity owned by PT XYZ, which is 108 m\(^3\), so the settlement will continue using the Lagrange Multiplier method.

Inventory calculations using the Lagrange Multiplier method can calculate the optimal production volume \((Q_{i,*})\) as follows:

\[
Q_{Li,*} = \left(\frac{W}{E_i}\right) \times Q_i^* \quad (9)
\]

Mindi Wood \(= \left(\frac{108}{712,626}\right) \times 243 = 37 \text{ m}^3\)

Mahogany Wood \(= \left(\frac{108}{712,626}\right) \times 173 = 26 \text{ m}^3\)

Based on the results of inventory calculations using the Lagrange Multiplier \((Q_{i,*})\) method above and warehouse capacity data, the total new warehouse inventory can be calculated using equation 8 as follows:

\[
7.88 \times \frac{37}{4,6} + 7.88 \times \frac{26}{4,6} \leq 108 \text{ m}^3
\]

\[
63,383 \text{ m}^3 + 44,539 \text{ m}^3 \leq 108 \text{ m}^3
\]

\[
107,922 \text{ m}^3 \leq 108 \text{ m}^3
\]

Based on the calculations above, the total new storage (warehouse) space obtained using the Lagrange Multiplier method is 107,922 m\(^3\). These results show optimal values because the orders made do not exceed the warehouse
capacity owned by PT XYZ, which is 108 m³, so there is no excess capacity in the mindi wood and mahogany wood material warehouses.

C. Calculation of Total Cost Using the Lagrange Multiplier Method

Total cost using the Lagrange Multiplier method ($\text{TC}_2$):

$$\text{TC}_2 = \sum_{i=1}^{n} \left( \frac{A_i D_i}{Q_{Li}} \right) + \sum_{i=1}^{n} \left( \frac{Q_{Li} C_i \alpha}{2} \right)$$

$$= \left( \frac{\text{IDR 5.000.000 \times 1160.931}}{37} \right) + \left( \frac{\text{IDR 5.000.000 \times 472.787}}{26} \right) + \left( \frac{37 \times \text{IDR 2.806.504 \times 0.07}}{2} \right) + \left( \frac{26 \times \text{IDR 2.253.690 \times 0.07}}{2} \right)$$

$$= (\text{IDR 156.882.568}) + (\text{IDR 3.634.423}) + (\text{IDR 90.920.577}) + (\text{IDR 2.050.858})$$

$$= \text{IDR 253.488.426}$$

D. Comparison of Total Inventory Costs

After knowing the inventory costs from both methods, the obtained inventory costs can be compared with the proposed method based on the Lagrange Multiplier method. The table below shows a comparison between the total inventory costs of the company and the results obtained from the Lagrange Multiplier method as follows:

<table>
<thead>
<tr>
<th>Table 9. Comparison of Total Company Inventory Costs with the Lagrange Multiplier Method</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Company Method</strong></td>
</tr>
<tr>
<td>IDR 270.707.599</td>
</tr>
</tbody>
</table>

From the Table 9, it can be concluded that the total inventory costs obtained using the Lagrange Multiplier method are smaller than the company’s total costs, namely IDR 17.219.173. So, it can be concluded that the Lagrange Multiplier method can provide the best solution with the total saving 6.36%, with the total inventory costs obtained being smaller than the total inventory costs in the company.

E. Inventory Planning using the Lagrange Multiplier Method for the Period February 2024 – January 2025

The first step in planning production using the Lagrange Multiplier method is forecasting the need for raw materials, such as mindi wood and mahogany. Therefore, to carry out forecasting, data plots will be carried out to determine existing data patterns. The data processed is the company’s historical data on material needs for mindi wood and mahogany wood from February 2023 to January 2024. The following is a historical plot image for each wood material:
After plotting historical data regarding the need for mindi wood and mahogany wood, it can be seen that the need for wood during the period February 2023 to January 2024 is included in the seasonal data pattern. So, the forecasting method that suits seasonal data patterns is:

a) Moving Average Method.
b) Single Exponential Smoothing Method.
c) Double Exponential Smoothing Method.
d) Winter Method

<table>
<thead>
<tr>
<th>Wood Type</th>
<th>Moving Average Method (3 months)</th>
<th>SES Method ($\alpha = 0, 28$)</th>
<th>DES Method ($\alpha = 0, 1$ dan $\beta = 0, 1$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mindi Wood</td>
<td>41,7833</td>
<td>38,3002</td>
<td>26,9551</td>
</tr>
<tr>
<td>Mahogany Wood</td>
<td>2,7896</td>
<td>3,68478</td>
<td>3,20265</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Wood Type</th>
<th>Winter Method ($\alpha = 0,1, \beta = 0,5, \gamma = 0,9$)</th>
<th>Winter Method ($\alpha = 0,5, \beta = 0,1, \gamma = 0,9$)</th>
<th>Winter Method ($\alpha = 0,9, \beta = 0,1, \gamma = 0,5$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mindi Wood</td>
<td>8,79659</td>
<td>2,62035</td>
<td>1,72386</td>
</tr>
<tr>
<td>Mahogany Wood</td>
<td>0,035100</td>
<td>0,010834</td>
<td>0,007267</td>
</tr>
</tbody>
</table>
Based on the comparison above, the smallest MSE value is found in the Winter forecasting method with $\alpha = 0.1$, $\beta = 0.1$, and $\gamma = 0.5$. So, the Winter forecasting method was chosen to predict the need for both mindi wood and mahogany wood from February 2024 to January 2025.

The MRC test will be performed when the least MSE value has been determined using the aforementioned predicting procedure. This is done to assess whether the need for wood material can be controlled using the forecasting approach. Here is a verification of predictions for all raw materials:

Mindi Wood

![Figure3. Moving Range Chart for Mindi Wood](image)

Based on the Mindi Wood MRC Test, the estimated needs are within control limits. The UCL value is -1,18 and the LCL is +1,18 with a moving range value of -0.55; 0.05; -0.30; -0.37; -0.48; -0.72; 0.27; -1.02; 0.37; -1.09; -1.05. So, all the data is under control.

Mahogany Wood

![Figure4. Moving Range Chart for Mahogany Wood](image)

Based on the MRC Mahogany Wood Test, the estimated needs are within control limits. The UCL value -0.07 and the LCL +0.07 with moving range value -0.04; 0.02; -0.05; 0.00; -0.04; 0.00; -0.03; -0.05; 0.00; -0.03; -0.06. So, all the data is under control. After the MRC test, a forecast of the respective needs for Mindi and Mahogany wood in the period February 2024 to January 2025 was obtained, namely:
Table 11. Forecasting the Need for Wood Materials (February 2024 - January 2025)

<table>
<thead>
<tr>
<th>No.</th>
<th>Month</th>
<th>Mindi Wood (m³)</th>
<th>Mahogany Wood (m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>February 2024</td>
<td>94.205</td>
<td>38.341</td>
</tr>
<tr>
<td>2</td>
<td>March 2024</td>
<td>104.739</td>
<td>42.921</td>
</tr>
<tr>
<td>3</td>
<td>April 2024</td>
<td>96.767</td>
<td>37.873</td>
</tr>
<tr>
<td>4</td>
<td>May 2024</td>
<td>96.424</td>
<td>41.331</td>
</tr>
<tr>
<td>5</td>
<td>June 2024</td>
<td>97.574</td>
<td>38.289</td>
</tr>
<tr>
<td>6</td>
<td>July 2024</td>
<td>100.645</td>
<td>39.776</td>
</tr>
<tr>
<td>7</td>
<td>August 2024</td>
<td>107.484</td>
<td>37.693</td>
</tr>
<tr>
<td>8</td>
<td>September 2024</td>
<td>97.77</td>
<td>38.823</td>
</tr>
<tr>
<td>9</td>
<td>October 2024</td>
<td>108.858</td>
<td>40.963</td>
</tr>
<tr>
<td>10</td>
<td>November 2024</td>
<td>98.664</td>
<td>38.884</td>
</tr>
<tr>
<td>11</td>
<td>December 2024</td>
<td>109.891</td>
<td>39.959</td>
</tr>
<tr>
<td>12</td>
<td>January 2025</td>
<td>119.652</td>
<td>42.667</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td><strong>1232,673</strong></td>
<td><strong>477,521</strong></td>
</tr>
</tbody>
</table>

F. Inventory Control using the Lagrange Multiplier Method (February 2024 – January 2025)

The EOQ (Q*) calculation will be calculated based on data on wood material requirements, inventory cost data, and purchase price data so that the order quantity can be calculated using the following formula:

\[
Q^* = \sqrt{\frac{2 \times D_t \times A_t}{\alpha \times C_t}}
\]

Mindi Wood = \(\sqrt{\frac{2 \times 1232,673 \times Rp 5,000,000}{0.07 \times Rp 2,806,504}}\) = 250 m³

Mahogany Wood = \(\sqrt{\frac{2 \times 477,521 \times Rp 5,000,000}{0.07 \times Rp 2,253,690}}\) = 174 m³

Based on existing warehouse capacity data and calculations using the EOQ (Q*) method, the total new storage space is calculated using the Economic Order Quantity (EOQ) method with:

\[
7.88 \times \frac{250}{4.6} + 7.88 \times \frac{174}{4.6} \leq 108 \text{ m}^3
\]

428,261 m³ + 298,070 m³ \leq 108 m³

726,331 m³ \leq 108 m³

Based on the calculations above, the total new storage (warehouse) space is 726,331 m³. These results are still not optimal because the order placed exceeds the warehouse capacity owned by PT XYZ, which is 108 m³, so the settlement will continue using the Lagrange Multiplier method.

Inventory calculations using the Lagrange Multiplier method can calculate the optimal production volume (Q₁*) using equation 8 as follows:

a) Mindi Wood = \(\left(\frac{108}{726,331}\right) \times 250 = 37 \text{ m}^3\)

b) Mahogany Wood = \(\left(\frac{108}{726,331}\right) \times 174 = 26 \text{ m}^3\)
Based on the results of inventory calculations using the Lagrange Multiplier \((Q_i^*)\) method above and warehouse capacity data, the total new warehouse inventory can be calculated \(Q_i^*\) using equation 8 as follows:

\[
7,88 \times \frac{37}{4,6} + 7,88 \times \frac{26}{4,6} \leq 108 \text{ m}^3
\]

\[
63,383 \text{ m}^3 + 44,539 \text{ m}^3 \leq 108 \text{ m}^3
\]

\[
107,922 \text{ m}^3 \leq 108 \text{ m}^3
\]

Based on the calculations above, the total new storage (warehouse) space obtained using the Lagrange Multiplier method is 107,922 m³. These results show optimal values because the orders made do not exceed the warehouse capacity owned by PT XYZ, which is 108 m³, so there is no excess capacity in the mindi wood and mahogany wood material warehouses.

1. Calculation of Total Cost Using the Lagrange Multiplier Method

Total cost from the Lagrange Multiplier method \((TC_2)\) using equation 10.

\[
= \left( \frac{\text{ IDR } 5,000,000 \times 1232.673}{37} + \frac{\text{ IDR } 2,806.504 \times 0.07}{2} \right) + \left( \frac{\text{ IDR } 5,000,000 \times 477.521}{26} + \frac{\text{ IDR } 2,253.690 \times 0.07}{2} \right)
\]

\[
= (\text{ IDR } 166,577.432) + (\text{ IDR } 3,634.423) + (\text{ IDR } 91,830.962) + (\text{ IDR } 2,050,858)
\]

\[
= \text{ IDR } 264,093.675
\]

Based on the results of the calculation above, namely calculating the total cost (total inventory costs), which was calculated using the Lagrange Multiplier method, the result was IDR 264,093.675.

D. Conclusion

The calculation of storage space using the Lagrange Multiplier method resulted in a result of 107,922 m³. These results show the optimal value because the orders made do not exceed the warehouse capacity of PT XYZ, which is 108 m³. The total cost (total inventory costs) calculated using the Lagrange Multiplier method resulted in IDR 253,488.426 with an order size for mindi wood of 37 m³ and mahogany wood of 26 m³.

The total cost (total inventory costs) calculated using the Lagrange Multiplier method produces a result of IDR 253,488.426. Compared to the company method with a total cost of IDR 270,707,599, the Lagrange Multiplier method can provide the best solution, and the total inventory costs obtained are smaller than the company’s total costs, namely IDR 17,219,173 or a savings of 6.36%.

E. References


