Inventory Control of Raw Material of Sawdust for The Production of Wood Pellets with Supply Chain Management Approach at PT Multi Energi Biomassa

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ABSTRACT
PT Multi Energi Biomassa is a company engaged in the production of renewable energy that located in Wonosobo, the product is wood pellet. The problem that occurs in company is the availability of raw materials of sawdust is always left a lot after production, this lead to accumulation of raw materials and increasing the cost of storage. This research is aims to control the inventory of raw materials so that there is no accumulation of raw materials so that total inventory cost can be reduced to a minimum. This research uses Supply Chain Management approach. The results of this research showed that bullwhip effect after forecasting of demand using exponential smoothing method with $\alpha = 0.95$ decreased from 1.127 to 1, where the value of bullwhip effect parameters 1,028. The optimal number of orders (EOQ) increased by 3.16% from 3,417 kg to 3,512 kg, but the frequency of request decreased from 300 times to 272 times. Total inventory costs without and with supply chain coordination decreased by 7.19% from Rp. 98,225,880 to Rp. 91,191,555. Inventory cost savings per period before and after coordination of supply chain is Rp. 7,064,325.

Keywords: *Inventory Control, Bullwhip Effect, Supply Chain Management, Economic Order Quantity, Total Inventory Cost*

1. INTRODUCTION

One of the common problems that are often faced by companies is the problem of inventory. Excess inventory can cause the accumulation of goods, causing the cost of storing these goods to increase, while a shortage of inventory results in the emergence of goods in the middle of the production process so that the target demand is not achieved. One of the reasons for this is supply chain management activities that have not been properly coordinated. Inventory is a source of material from a production process to meet demand, without inventory the company cannot run its production.

PT Multi Energi Biomass is a company engaged in the production and marketing of renewable energy, the product is wood pellets. The raw material used is sawdust waste from the timber industry. The problem that exists at PT MEB is the availability of sawdust raw materials which always do not run out after production, this results in the accumulation of raw materials in the warehouse, causing high storage costs. The graph of the use of raw sawdust in the company for 12 months can be seen in Figure 1 below.

Seeing the consequences of inventory procurement, the company must plan and control optimal inventory. Planning and controlling this inventory requires a management concept that can regulate the flow of goods and information that is precise and accurate, namely the concept of Supply Chain Management. The target to be achieved in the concept of Supply Chain Management is to increase profits by paying attention to the relationship between supply chain actors

Several studies that discuss the issue of availability can be seen among the others. Research on inventory management in the automotive industry, states that inventory is considered more than 7% of the company's total liquidity [1]. Research on the inventory of cooperative warehouse stocks that often

experience excess inventory or shortage in inventory data collection [2]. Problems that address the gap between demand and supply due to sudden demand from consumers [3]. The study discusses the problem of the availability of raw materials for companies that are often inappropriate so that the company's production does not reach the target within the specified time range due to the absence of accurate information related to customer demand [4].

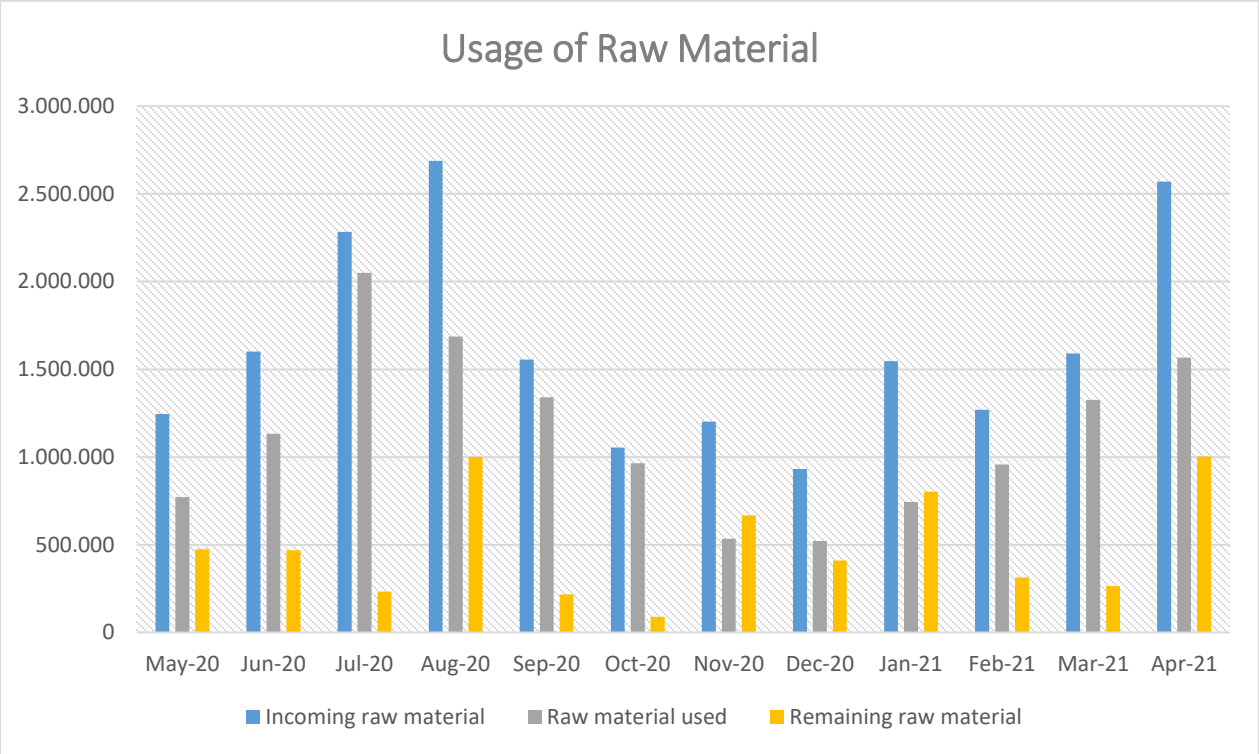

Figure 1. Usage of raw material

The difference between this research and previous research is that the target in this study focuses on suppliers who supply goods to the company and suppliers from suppliers who supply goods to the company. The purpose of this study is to control the inventory of raw materials so that there is no accumulation of raw materials, so that the total cost of inventory can be reduced to a minimum.

2. METHODS

This study uses a Supply Chain Management approach by focusing on companies with suppliers and suppliers from the company's suppliers. The primary data in this study are raw material inventory data, production data, demand data, ordering costs and storage costs. The secondary data in this study are previous research journals related to Supply Chain Management. Data collection was carried out by direct field observations, conducting interviews with workers and suppliers and completing research references with journals and reference books related to Supply Chain Management.

A supply chain is a network of companies that work together to create and deliver a product to the end user. These companies usually include suppliers, manufacturers, distributors, retailers and supporting companies such as logistics service companies [5]. All elements in supply chain management cannot run alone, but must coordinate with other supply chain management elements so as to produce synergies and produce efficiency and effectiveness.

Forecasting

Forecasting is a projection for the product or service of a company that controls production, capacity and scheduling systems and becomes input for financial planning, marketing and human resources (Heizer and render, [6]. Forecasting is done not always perfect or there will be errors, either a little or a lot. Therefore, forecasting is expected to be carried out with the smallest possible error value (Rangkooti, 2004). Error measurements that can be used are Average Error (AE), Mean Absolute Deviation (MAD), Mean Squared Error (MSE), MAPE (Mean Absolute Percentage Error), tracking signal. The benefit of error forecasting is to monitor observations that are uncertain or of extreme value, so that the data is properly controlled and removed from the data if necessary and also determines whether the forecast method can no longer be used and requires improvement [7].

Bullwhip Effect

Some of the challenges that must be faced in the supply chain include the bullwhip effect, where the bullwhip effect is an increase in demand uncertainty from downstream to upstream in a supply chain [9]. The formula for calculating the bullwhip effect can be seen in the following equation.

$$\text{Bullwhip effect} = \frac{\text{CV order}}{\text{CV demand}}$$

$$\text{CV (order)} = \frac{\text{s (order)}}{\text{mu (order)}}$$

$$\text{CV (demand)} = \frac{\text{s (demand)}}{\text{mu (demand)}}$$

$$\text{Parameter} = BE \geq 1 + \frac{2L}{P} + \frac{2l^2}{P^2}$$

Description:
BE = Bullwhip effect
CV = Coefficient of variance
s = Standard deviation
mu = Mean
L = Lead time
P = Period

Data processing in this study is to convert the number of requests into raw material needs, then forecasting demand for the next 12 periods. After forecasting the demand, the next step is to calculate the value of the bullwhip effect before forecasting and after forecasting to find out whether the company is experiencing a bullwhip effect. The next calculation is to calculate the value of the Economic Order Quantity before and after implementing supply chain coordination, then proceed with calculating the total inventory cost before and after implementing supply chain coordination.

Economic Order Quantity

Economic Order Quantity is one of the oldest and widely known inventory control techniques, this inventory control method answers two important questions, namely when to order and how much to order. The formula for calculating the Economic Order Quantity can be seen in the following equation [7].

EOQ without SC

$$Q* = \sqrt{\frac{2.O.D}{C}}$$

EOQ with SC

$$Q* = \sqrt{\frac{2(Oper + Osup).D}{Cper + Csup}}$$

Frequency of order without SC **Frequency order with SC**

$$N = \frac{D}{Q*} \qquad N = \frac{D}{Q*}$$

Description:
Q = The average number of orders for the company's raw materials per order
C = Storage cost
D = Average amount of raw material inventory per month
N = Frequency of company orders
O = Ordering fee every time you order
Q* = Order quantity in EOQ system units
Opera = Cost of messages issued by the company
Osup = Cost of the message issued by the supplier
Cper = Savings cost incurred by the company
Csup = Storage costs incurred by suppliers

Total Inventory Cost

The results of EOQ calculations with and without supply chain coordination are used to determine the total inventory cost. Calculation of total inventory cost is done with supply chain coordination and without supply chain coordination. The formula for calculating total inventory costs with and without supply chain coordination can be seen in the following equation.

Total inventory cost without supply chain coordination **Total inventory cost with supply chain coordination**

$$TC = \left(\frac{D}{Q}\right)C + \left(\frac{Q}{2}\right)h \qquad TC = \left(\frac{D}{Q*}\right)C + \left(\frac{Q*}{2}\right)h$$

Description:
TC = Total cost in a year
D = Demand per year
Q = Optimal order size
C = Ordering cost per year
H = Storage cost
Q* = Optimal order size after coordination between supply chains

3. RESULTS AND DISCUSSION

Forecasting

Forecasting the demand for wood pellets, which previously had the number of requests converted into the amount of sawdust needed. The forecasted demand data is demand data for 12 periods from April 2021 to May 2021. This forecast uses the exponential smoothing method with a constant value of 0.95 because the demand data plot formed is a fluctuating or irregular pattern, the method used is the exponential smoothing method, where the more irregular the data plot, the closer the constant value to 1 and vice versa. Forecasting results for the next 12 periods can be seen in table 1 and figure 2 below.

Bullwhip Effect

The results of this demand forecast are used to determine the parameters for the calculation of the bullwhip effect. The calculation of the bullwhip effect parameter can be found by first determining the supply and demand parameter values. Parameters of inventory, demand and forecasting results can be seen in table 2 below. The calculation of the bullwhip effect can be known after knowing the parameters of

supply, demand and demand forecasts to see how the bullwhip effect compares before and after forecasting demand.

The actual value of the bullwhip effect is greater than the parameter of the bullwhip effect, this indicates that before the demand forecasting was carried out the company experienced a gap between the amount of demand and the amount of inventory. The bullwhip effect value after forecasting demand is smaller than the bullwhip effect parameter, this indicates that the company does not experience a gap between the amount of demand and the amount of inventory. The results of the calculation of the bullwhip effect can be seen in table 3 below.

Table 1. Forecasting for the next 12 periods

Period	t	Forecasting
May-21	13	788851
Jun-21	14	970685
Jul-21	15	824414
Aug-21	16	1295657
Sep-21	17	1012358
Oct-21	18	435100
Nov-21	19	451390
Dec-21	20	750554
Jan-22	21	779584
Feb-22	22	588125
Mar-22	23	595705
Apr-22	24	656799
Rata-rata		**470,763.9**

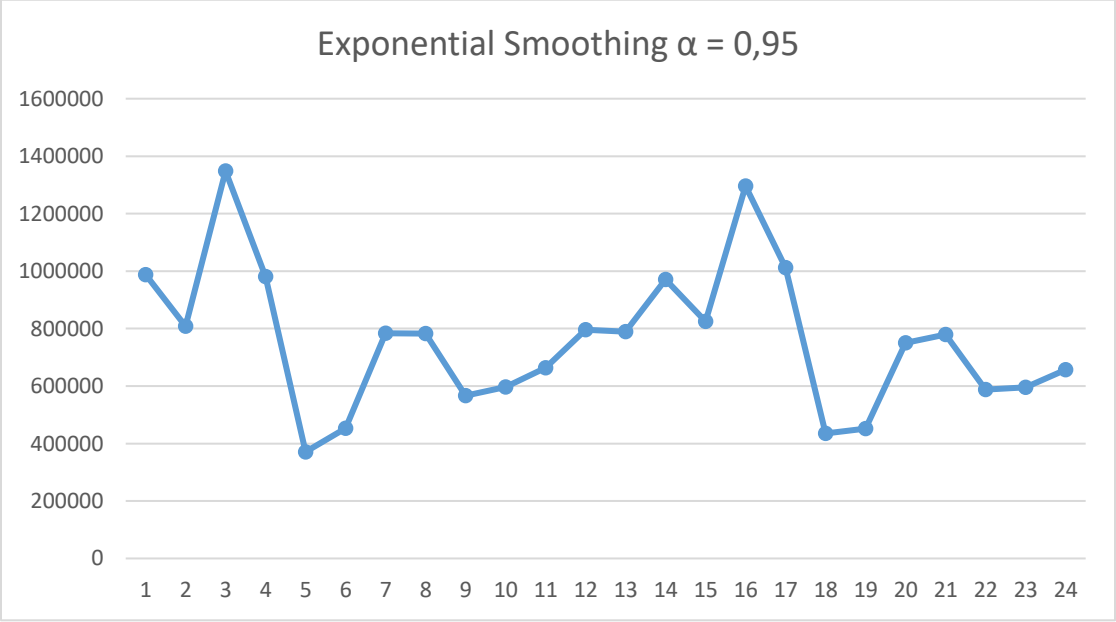

Figure 1. Graph of forecasting for the next 12 periods

Table 2. Inventory, demand and forecasting parameters

	N	Sum	Mean	Standard Deviation
Inventory	12	17,178,148	1,431,512	560,252.42
Demand	12	16,612,989	1,384,416	480,887.4
Demand Forecasting	12	16,236,623	1,353,052	470,763.9

Table 3. Bullwhip effect

Bullwhip Effect Parameter	Actual Bullwhip Effect	Bullwhip Effect after Forecasting
1.028	1.127	1.005

Economic Order Quantity

The calculation of the Economic Order Quantity is carried out in 2 ways, namely calculations without implementing supply chain coordination and calculations using supply chain coordination. The value of the economic order quantity without supply chain coordination is 3,417 kg, while the value of the economic order quantity after implementing supply chain coordination is 3,525 kg. The frequency of orders without supply chain coordination is 300 times, while the frequency of orders after supply chain coordination is 272 times. Based on the calculation of the economic order quantity, optimal orders increased by 3.16% but the frequency of orders decreased by 28 times or by 10.29%. The results of the calculation of the economic order quantity can be seen in table 4 below.

The increase in orders by 3.16% occurred because the calculation of economic order quantity with supply chain coordination involved ordering costs and storage costs incurred by suppliers as well, so ordering costs and storage costs were getting bigger. The larger the comparison between ordering and storage costs, the larger the order quantity as well. The decrease in the frequency of orders by 10.29% occurred due to the increasing value of the optimal order quantity. Calculation of the optimal ordering frequency is by comparing the number of requests per year with the optimal order quantity value, so that the greater the optimal order value, the smaller the optimal ordering frequency. The results of calculating the optimal ordering frequency can be seen in table 5 below.

Table 4. Economic Order Quantity

EOQ without Coordination of Supply Chain (kg)	EOQ with Coordination of Supply Chain (kg)	Increasing (%)
3,417	3,525	3.16

Table 5. Frequency of Optimal Order

Frequency without Coordination of Supply Chain (kg)	Frequency with Coordination of Supply Chain (kg)	Decreasing (%)
300	272	10.29

Total Inventory Cost

The results of EOQ calculations with and without supply chain coordination are used to determine the total inventory cost. Calculation of total inventory cost is done with supply chain coordination and without supply chain coordination. Total inventory cost is used to find the total cost of inventory in EOQ without supply chain coordination and supply chain coordination. It is known that the average demand for wood pellets is 761.429 kg of wood pellets which is equivalent to 1,384,416 kg of sawdust (conversion of sawdust to wood pellets is on average 55%).

The total cost value decreased by 7.19% due to the optimal order value in the EOQ calculation with supply chain coordination. Optimal order value with supply chain coordination has an impact on the total cost if coordination is carried out between supply chains. The greater the optimal order value with supply chain coordination, the smaller the total cost with supply chain coordination produced will also be smaller. The results of the calculation of the total inventory cost with and without supply chain coordination can be seen in table 6 below.

Table 6. Total Inventory cost

Total inventory cost without Coordination of Supply Chain (Rp)	Total inventory cost with Coordination of Supply Chain (Rp)	Saving (Rp)	Saving (%)
98,255,880	91,191,555	7,064,325	7.19

4. CONCLUSION

Based on the analysis and discussion above, the conclusion in this study is that PT Multi Energi Biomassa experienced a bullwhip effect before forecasting demand by showing that the actual bullwhip effect value was greater than the bullwhip effect parameter value. Meanwhile, after forecasting the demand, PT Multi Energi Biomassa did not experience a bullwhip effect, as indicated by the value of the bullwhip effect after forecasting was lower than the value of the bullwhip effect parameter.

The optimal order quantity (EOQ) before supply chain coordination is 3,417 kg. The optimal order quantity (EOQ) after supply chain coordination is 3,525 kg. Optimal order volume (EOQ) increased by 3.16%. Inventory cost savings per period by involving supply chain coordination is Rp. 7,064,325. The total inventory cost incurred by the company without supply chain coordination with supply chain coordination resulted in savings of 7.19% from Rp. 98,225,880 to Rp. 91,191,555.

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