

SISTEM PERSEDIAAN UNTUK BAHAN KEMAS DENGAN PERMINTAAN PROBABILISTIK MENGGUNAKAN METODE *JOINT REPLENISHMENT* PADA PERUSAHAAN COCOA

AN INVENTORY SYSTEM FOR PACKAGING MATERIAL UNDER THE PROBABILISTIC DEMAND USING JOINT REPLENISHMENT METHOD AT COCOA COMPANY

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Abstrak

Perusahaan XYZ adalah perusahaan yang bergerak di bidang industri cocoa yang ada di Bandung. Pada saat ini, Perusahaan XYZ mengalami masalah dalam mengendalikan sistem persediaan bahan kemasnya karena hanya ada satu supplier yang menyediakan bahannya, lead time yang bervariasi, jumlah stok bahan kemas yang tinggi dan menumpuk di gudang. Tujuan dari riset ini adalah untuk meminimasi total biaya persediaan, sistem ini terdiri dari tiga tahap. Pertama, menentukan permintaan untuk bahan kemas dan menguji distribusinya, klasifikasi menggunakan analisis ABC dan menguji distribusi dari lead time. Kedua, menentukan economic order interval dan order quantity, stok pengaman dan reorder point. Ketiga, menghitung total biaya persediaan. Analisis sensitivitas dilakukan untuk melihat efek dari perubahan parameter variabel input yaitu biaya pesan dan biaya simpan pada total biaya persediaan. Analisis sensitivitas dilakukan dengan rentang 5% hingga 25%. Dari riset yang telah dilakukan, sistem persediaan aktual pada perusahaan ini belum efisien karena kebijakan aktual yang belum optimal. Hal tersebut bisa dilihat dari jumlah overstock yang menghasilkan biaya tertanam yang tinggi, maka dari itu kebijakan aktual pada Perusahaan XYZ butuh perbaikan. Dari total 25 SKU bahan kemas, sistem persediaan yang diusulkan pada paper ini bisa menghemat sebesar 83.24% yaitu sebesar Rp174,342,981,-. Sistem usulan mempertimbangkan variasi dari lead time dan telah meningkatkan performansi persediaan.

Keyword : *joint replenishment, economic order interval, economic order quantity, safety stock, reorder point, Inventor Turnover (ITO)*

Abstract

Company XYZ is a company runs in the cocoa industry located in Bandung. Currently, Company XYZ has the problem in controlling inventory system of packaging materials because there is only one supplier who supply the material, variation of lead time, high stocks of packaging material that pile up in the warehouse. The purpose of this research to minimize the cost of total inventory, this system consists of three stages. First, determining the demand for packaging material and testing the distribution of demand, classification using ABC analysis and testing distribution of lead time. Second, determine the economic order interval and order quantity, safety stock and reorder point. Third, calculate the total inventory cost. Sensitivity analysis is performed to see the effect of the change of variable parameter input of ordering cost and holding cost to total inventory cost. Sensitivity analysis is performed with a range of 5% to 25%. From the research that has been done, actual inventory system in this company has not been efficient because the actual policy is still not optimal. It can be seen from the number of overstocks that generate high embedded costs, then the actual policy in Company XYZ need improvement. From the total 25 SKUs of material packaging, Inventory system proposed in this paper can save 83.24% that is Rp171,342,981,-. The proposed system that considering variation of lead time has improved inventory performance.

Keyword : *joint replenishment, economic order interval, economic order quantity, safety stock, reorder point, Inventor Turnover (ITO)*

1. Introduction

Company XYZ is a company runs in the cocoa industry located in Bandung. Company XYZ will send their product to customer, the amount of packaging material inventory will impact on customer satisfaction, calculating the optimum safety stock and determining the right reorder point will result in high customer satisfaction and can minimize total inventory cost. Since the packaging is a dependent goods to finished goods, from the Figure 1 the demand listed is a demand based on the sale of finished goods. Demand, beginning inventory, and ending inventory that contained in the Figure 1 is the sum of all packaging SKUs.

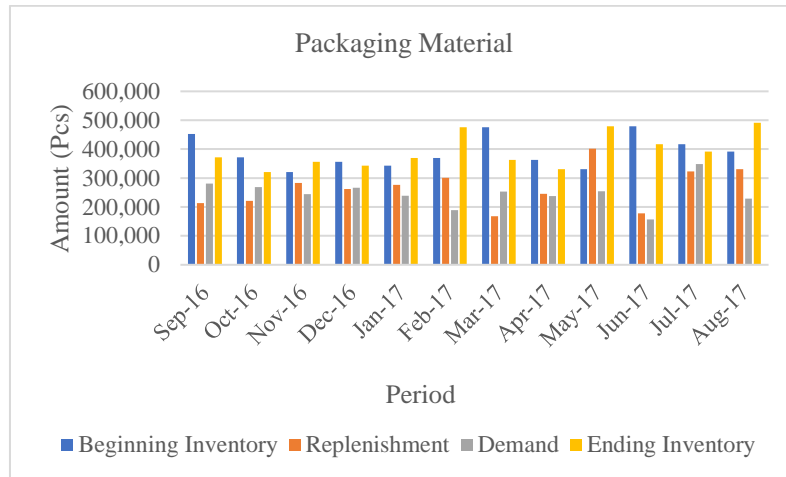


Figure 1. Graph of Packaging Material Inventory

If seen from amount of ending inventory for one year and its safety stock. When compared between the numbers of safety stock and ending inventory looks very much the amount of excess inventory and this condition causes overstock and lead to high inventory cost resulting in the company loss. If seen in Aug-17 the number of overstock for the entire SKU reaches 382.194 pcs. Companies need to improve policies for their inventory packaging material.

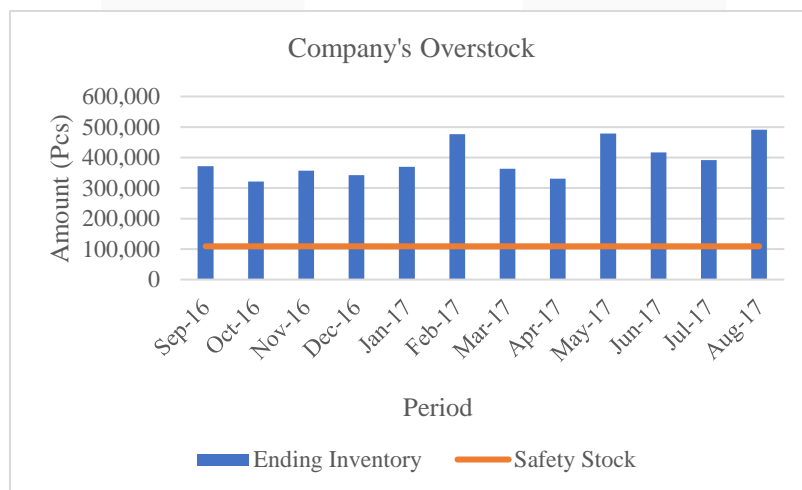


Figure 2. Comparison of Ending Inventory and Safety Stock

From the Figure 3 it can be seen the number of embedded cost The amount of embedded cost is quite high, from the graph in Aug-17 the cost reaching Rp 22.882.306.996. The embedded cost is obtained from the gap between ending inventory and safety stock in Figure 2 which is multiplied by the price of the packaging material of each SKU.

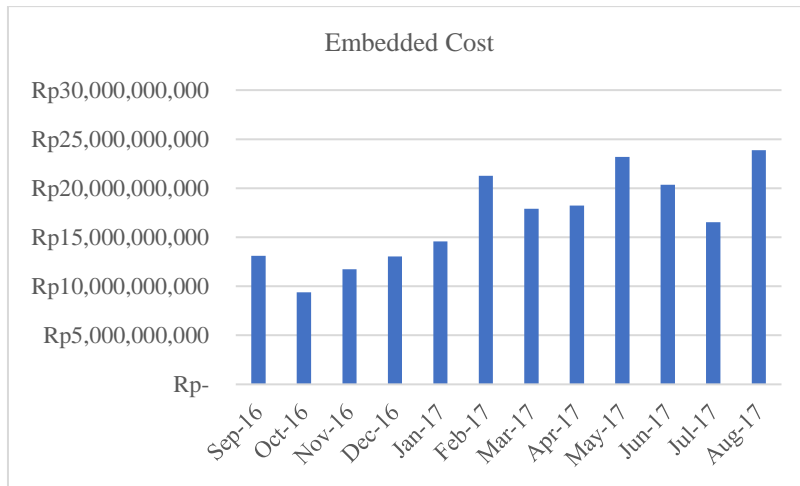


Figure 3. Embedded Cost in the Period

2. Literature

2.1 Inventory

According to reference [1] inventory is idle resources whose existence awaits further process. Further process here may be production activities on manufacturing systems, marketing activities on distribution systems, or consumption activities in household systems, offices, and so on.

2.2 Inventory Cost

Inventory costs incurred as a result of inventories over a given time horizon. The components in the cost of inventory are:

1. Purchasing Cost
2. Procurement Cost
3. Holding Cost
4. Shortage Cost
5. Systemic Cost

2.3 Inventory Turnover (ITO)

According to reference [8] in addition to both cost performance measures and service levels, in the business system often used inventory turnover as a measure of capital effectiveness and inventory management system capabilities to create profit. The ITO can be measured from:

$$ITO = \frac{V_p}{V_T} \tag{1}$$

Where:

- V_p : Annual sales volume
- V_T : Yearly average inventory volume

2.4 Distribution Test

Test distribution used to test the distribution of demand packaging material and lead time. The test was performed using One-sample Kolmogorov-Smirnov. After doing the testing it is proved that the data is normally distributed because p value > 0,05

2.5 ABC Analysis

The principle of ABC analysis is to classify the types of goods based on the level of annual investment absorbed in the provision of inventory for each type of goods. ABC classification is using principle 80-20 or Pareto law which about 80% of the total supply of materials representing 20% of the material in the inventory. ABC analysis

is used to determine investment decisions and can be applied to companies with different types of materials and different values.

2.6 Probabilistic Model

According to reference [13] parameters in this model such as demand, lead time, inventory costs are varies in the real condition. The use of probabilistic model is because if using a deterministic model is not sensitive to such things. The equation used to determine the total inventory cost is using equations Economic Order Interval (EOI)-Multiple Items. The economic order interval can be obtained by minimizing the total annual cost. Neglecting stock out cost, the formulation is:

1. Total annual cost for an order interval of T years

$$TC(T) = \sum_{i=1}^n P_i R_i + \frac{C+nc}{T} + \frac{TF}{2} \sum_{i=1}^n P_i R_i \quad (2)$$

2. Economic order interval in years

$$T^* = \sqrt{\frac{2(C+nc)}{F \sum_{i=1}^n P_i R_i}} \quad (3)$$

3. Maximum inventory each item

$$E_i = \frac{R_i T}{N} + \frac{R_i L}{N} = \frac{R_i(T+L)}{N} \quad (4)$$

If lead time is normally distributed, then the formulation used for reorder point optimization is:

$$B = \bar{M} + Z_\sigma = D\bar{L} + ZD\sigma_L \quad (5)$$

2.7 Joint Replenishment Method

Determination of Economic Order Interval (T^*) and Optimal Order Quantity (Q^*) packaging material the proposed system by using joint replenishment method, step to determination T^* and Q^* are as follows:

1. Determine the annual demand per SKU by using the equation:

$$P_i R_i \quad (6)$$

2. Calculate total annual demand for all SKU
3. Determination of Economic Order Interval (EOI) by using the equation:

$$T^* = \sqrt{\frac{2(C+nc)}{F \sum_{i=1}^n P_i R_i}} \quad (7)$$

With:

$$F = \frac{\text{Holding Cost per year}}{\text{Total Asset}} \quad (8)$$

4. Determine optimal order quantity for all SKU by using the equation:

$$Q^* = R_i \times T^* \quad (9)$$

5. Calculate ordering cost by using the equation:

$$TC_p = \frac{C+nc}{T^*} \quad (10)$$

6. Calculate holding cost by using the equation:

$$TC_s = \frac{T^* F}{2} \sum_{i=1}^n P_i R_i \quad (11)$$

7. Calculate total inventory cost for all SKU by using the equation:

$$TC = TC_p + TC_s \quad (12)$$

Next to determine the Safety Stock (SS) and Reorder Point (B) for the proposed system are as follows:

1. Determine Safety Stock (SS) for each SKU by using the equation:

$$SS = ZD\sigma_L \quad (13)$$

2. Determine Reorder Point (B) for each SKU by using the equation:

$$B = \bar{M} + Z_\sigma = D\bar{L} + ZD\sigma_L \quad (14)$$

Notation:

P_i	: Price per unit
R_i	: Total requirement
T^*	: Economic Order Interval in year
C	: Order cost for the joint order
n	: Total number of joint order items
c	: Order cost associated with each individual item
F	: Annual holding cost as a fraction of purchase cost
Q^*	: Optimal Order Quantity
TC_p	: Ordering cost
T	: Order interval in years
m	: Number of annual orders
TC_s	: Holding cost
TC	: Total inventory cost
SS	: Safety stock
B	: Reorder point
D	: Rate constant demand per period
\bar{L}	: Average lead time in the period
σ	: Standard deviation or demand during lead time
σ_L	: Standard deviation of lead time

3. Results and Analysis

3.1 Results

From the total SKU packaging material amounting to 12 for Class A and B, each SKU has lead time data. Each SKU has its own ordering frequency in each month. After testing the data distribution, the distribution of lead time is normal distribution for all 12 SKUs. Here is the example of determination of Economic Order Interval (T^*) and Optimal Order Quantity (Q^*) packaging material for the proposed system by using joint replenishment method.

SKU	: H-202
Description	: Plastic bag PE, Sealed gusset, C. Butter, 390/700 x 680 x 0.1 mm 25 kg
Unit	: Pcs
Class	: A
Total requirement (R_i)	: 918,474 Pcs
Price per unit (P_i)	: Rp 72,808,-
Ordering cost (C)	: Rp 250,000,-
Fraction of holding cost (F)	: 0,014990

Step to determination T^* and Q^* are as follows:

Step 1: Calculate annual demand

$$P_i R_i = \text{Rp } 72,808 \times 918,474 \text{ Pcs} = \text{Rp } 66.872.755.604$$

Step 2: Calculate total annual demand = Rp 158,900,270,549

Step 3: Determination of Economic Order Interval (EOI)

$$T^* = \sqrt{\frac{2(C + nc)}{F \sum_{i=1}^n P_i R_i}}$$

$$T^* = \sqrt{\frac{2(Rp250,000 + (0))}{0,0149 \times 158,900,270,549}}$$

$$= 0,01448 \text{ years} = 5,28 \text{ days}$$

Step 4: Determination of Optimal Order Quantity for all SKU

$$Q^* = R_i \times T^*$$

$$= 918,474 \text{ Pcs} \times 0,01448$$

$$= 13,307 \text{ Pcs per order}$$

Step 5: Calculate ordering cost

$$TC_p = \frac{C + nc}{T^*}$$

$$TC_p = \frac{Rp250,000 + 0}{0.0149} = Rp 17,255,364$$

Step 6: Calculate holding cost

$$TC_s = \frac{T^* F}{2} \sum_{i=1}^n P_i R_i$$

$$TC_s = \frac{0.01448 \times 0.0149}{2} \times Rp 158,900,270,549 = Rp 17,255.364$$

Step 7: Calculate total inventory cost

$$TC = TC_p + TC_s$$

$$= Rp 17,255,364 + Rp 17,255,364$$

$$= Rp 34,510,729$$

Next to determine the Safety Stock (SS) and Reorder Point (B) for the proposed system are as follows:

$$\bar{L} = 102.0732 \text{ days} = 0.2796 \text{ years}$$

$$\sigma_L = 55.0434 \text{ days} = 0.1508 \text{ years}$$

$$SS = ZD\sigma_L$$

$$= 1.29 \times 918,474 \text{ Pcs} \times 0.1508$$

$$= 17,867 \text{ Pcs}$$

$$B = \bar{M} + Z_\sigma = D\bar{L} + ZD\sigma_L$$

$$= (918,474 \text{ Pcs} \times 0.2796) + 17,8677 \text{ Pcs}$$

$$= 435,531 \text{ Pcs}$$

3.2 Analysis

Table 1. Cost Comparison Between Existing and Proposed Inventory System

Coponent of Inventory System	Actual Inventory System	Proposed Inventory System
Ordering Cost	Rp 116,750,000	Rp 17,255,364
Holding Cost	Rp 89,103,710	Rp 17,255,364
Total Inventory Cost	Rp 205,853,710	Rp 34,510,729
Save	Rp 171,342,981	
% Save	83,24%	

In Table 1 it can be seen the comparison between the total inventory cost of existing inventory system with the proposed inventory system, seen from the total inventory cost is reduced and the proposed system saves Rp171,342,981 or 83,24% in percentage.

According to reference [12] sensitivity analysis is the stages of the modeling system to validate the inventory model to be built or developed. Two important issues in the sensitivity analysis are as follows:

1. Find response of optimal solutions generated to changes in the input values
2. Find out how the big error occurs (loss profits or savings)

Sensitivity analysis is performed to see the effect of the change of variable parameter input of ordering cost and holding cost to total inventory cost. Sensitivity analysis is performed with a range of 25% decrease to 25% increase.

Sensitivity Analysis of Ordering Cost

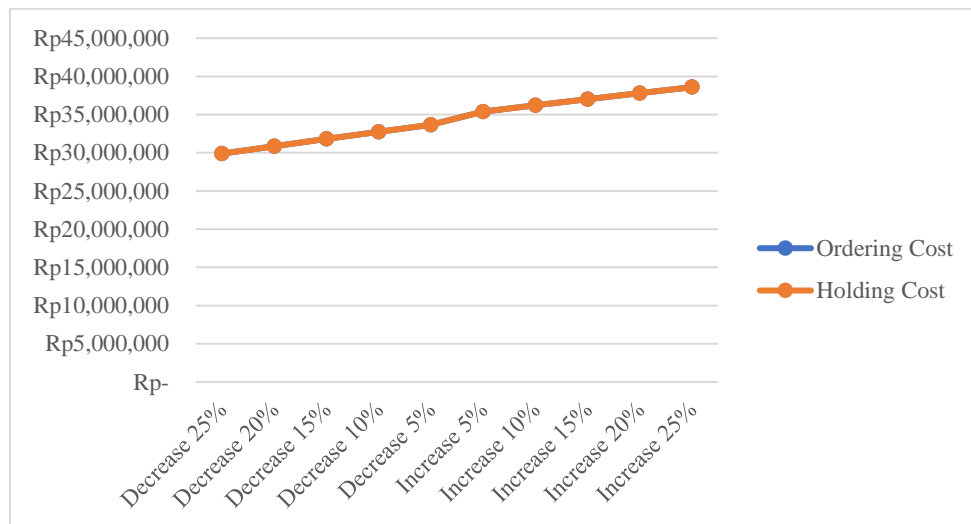


Figure 4. Sensitivity Analysis

Parameters used to perform sensitivity analysis are ordering cost and holding cost. This is because there is a possibility that the value of the parameter changes volatile either decrease or increase. Ordering cost and holding cost are the constituent components of total inventory cost. The increase and decrease of the parameters is assumed to vary from 5% to 25%. It can be concluded from Figure 4 that the proposed solution is optimal because if ordering cost has increased then it is sensitive total inventory cost. And Figure 4 also shows that the total cost of inventory is influenced by the holding cost. This is because the more packaging material stored in the warehouse the greater the holding cost. Ordering cost and holding cost have the same value.

4. Conclusion

Packaging material inventory system in Company XYZ is still not optimal when compared with proposed inventory system because the proposed cost is smaller with total inventory cost of Rp34,510,729 compared to the existing of Rp205,853,710. With savings of 83.24% then the proposal system is better.

Proposed system or recommendation given for packaging material inventory system at Company XYZ include:

1. Classify packaging materials using ABC analysis based on annual demand and value of investment absorption.
2. Determination of optimal order interval (T^*), optimal order quantity (Q^*), and frequency ordering using joint replenishment method.
3. Determination of safety stock (SS) and reorder point (B) of packaging materials for all SKU by considering variations of lead time.
4. Calculate the total inventory costs for one year.

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