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Using of EOQ and EPQ Methods in Minimizing Inventory Cost of Crude Palm Oil

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ABSTRACT

Excess or lack of inventory that is too large is a problem that can trigger increased costs so that companies do not get the benefits they should. The purpose of this study is to minimize the cost of inventories of crude palm oil using the EOQ (Economic Order Quantity) method and EPQ (Economic Production Quantity) methods at PT. Perkebunan Nusantara IV (Persero) Medan. From the results it is known that economic orders according to the EOQ method in 2017 amounted to 2.741,222 tons and in 2018 amounted to 2.825,927 tons. The difference in total inventory costs generated using the EOQ method and company conditions in 2017 amounted to Rp71.605.439.976,17 and in 2018 amounting to Rp60.884.174.907,3. The optimal amount of production (EPQ) in 2017 and 2018 was 146.226,147 tons. The difference in total inventory costs generated using the EPQ method and the condition of the company in 2017 and 2018 amounted to Rp102.771.704.121,63.

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1. INTRODUCTION

Inventory is a resource or raw material that is stored and will be used now or in the future to meet customer needs. For the smooth production process, inventory is very important.

Basically the need for an inventory control system arises because of the problems that the company may face in the form of excess or lack of inventory. If the inventory is too large it will add storage costs and the possibility of quality losses that can not be maintained. Conversely, if too little inventory results in not meeting customer needs (Yus, 2013).

Each company in the smooth production process has a different amount of raw material inventory. A common problem commonly faced by companies is that they have not been able to carry out production planning optimally with the amount of available inventory. Companies must be able to meet customer needs in the production process. But usually the company only does the production process based on previous requests. Because companies need to plan and optimize production to minimize inventory costs and obtain maximum profits.

2. RESEARCH METHODE

EOQ Methods

In 1915 the EOQ Method (*Economic Order Quantity*) first developed by Ford Harris and RH Wilson. The method used to determine the most economical ordering of raw materials is the EOQ Method. This method is very suitable for processing finished goods inventory problems (Agus, 2009).

The basic assumption for using the EOQ method is that demand can be determined with certainty and constant so that the cost of stock out and related to its capacity does not exist, requests are received immediately and definitely, and the price of items is constant.

EOQ Inventory Method, graphically can be seen in Figure 1:

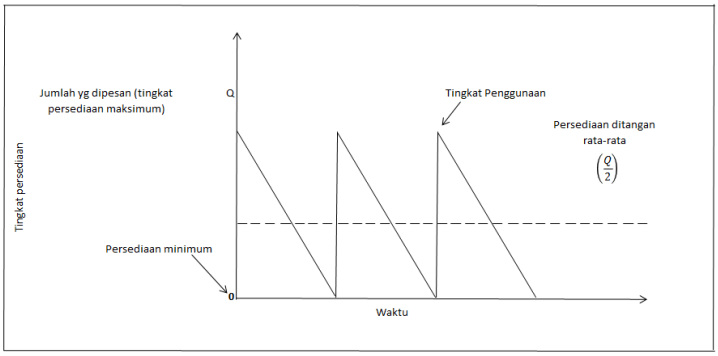

Figure 1: Graph of the EOQ Method (Heizer and Render, 2005)

From Figure 1 it can be seen that the line connecting Q with time represents the rate at which inventory is spent based on the level of usage over a certain period of time. Usage is assumed to be known with certainty and constant as indicated by the broken line and it can also be seen that inventory is never below zero.

The mathematical objective of this model starts with the ordering cost component (*ordering cost*) which depends on the number (*frequency*) of orders in a period, where the frequency of orders depends on:

1. The amount of goods needed for one period (D)
2. The optimal number of orders for each order (Q^*)

From the description above, the order frequency can be determined as follows:

$$F = \frac{D}{Q^*} \tag{1}$$

With normal cycle:

$$S_O = \frac{Q^*}{D} \tag{2}$$

Ordering cost formulated as follows:

$$O_C = \frac{D}{Q^*} \times S \tag{3}$$

Storage cost (holding cost) formulated as follows:

$$H_C = \frac{Q^*}{2} \times H \tag{4}$$

EOQ occurs when:

Ordering cost = Storage cost

$$\frac{D}{Q^*} \times S = \frac{Q^*}{2} \times H$$

$$2DS = HQ^*$$

$$Q^{*2} = \frac{2DS}{H}$$

$$Q^* = \sqrt{\frac{2DS}{H}}$$

So that the number of economic orders obtained in one period, namely:

$$Q^* = \sqrt{\frac{2DS}{H}} \quad \text{or} \quad EOQ = \sqrt{\frac{2DS}{H}} \tag{5}$$

To determine the total minimum inventory cost in the EOQ method the formula is used:

$$TIC = \frac{D}{EOQ}S + \frac{EOQ}{2}H \tag{6}$$

EPQ Method

EPQ Method (*Economic Production Quantity*) is the result developed from the supply model whose raw materials are jointly produced and used by the company itself as finished products. Optimizing production output by minimizing production costs and storage costs is the understanding of the EPQ Method (*Economic Production Quantity*) (Zulian, 2002).

The EPQ method can be developed through the following images:

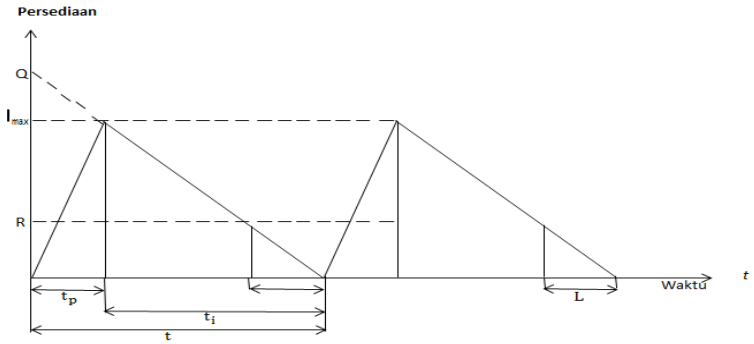

Figure 2: Graph of the EPQ Method (Subagyo, Marwan and Handoko, 2000)

In figure 2 we see that the number of production each round must meet the needs/ demands during t or notated $Q = D.t$

When t_i (*production process stops*) there is a reduction in inventory with D (*average distribution*). If the inventory has reached the level R then the production procurement must be held for a long time L (*time to reproduce*). By distributing t_i p then the average inventory becomes:

$$\frac{Q}{P} = \left(\frac{P-D}{2}\right) = \frac{Q(P-D)}{2P} \tag{7}$$

From equation (7) we get the average cost of storage $\frac{Q(P-D)}{2P}.C_c$ Because number of production rounds is $\frac{D}{Q}$ then the average cost of procurement $\frac{D}{Q}C_s$, so TIC becomes:

$$TIC = \frac{Q(P-D)}{2P}.C_c + \frac{D}{Q}.C_s \tag{8}$$

Equation (7) is differentiable with Q, then:

$$\frac{dTIC}{dQ} = \frac{(P-D)}{2P}.C_c - \frac{D}{Q^2}.C_s = 0$$

$$\frac{(P-D)}{2P}.C_c = \frac{D}{Q^2}.C_s$$

$$\frac{1}{Q^2} = \frac{\frac{(P-D)}{2P}.C_c}{D.C_s}$$

$$Q^2 = \frac{2.D.P.C_s}{(P-D).C_c}$$

$$Q_O = \sqrt{\frac{2.D.P.C_s}{(P-D).C_c}}$$

In order to obtain the formula in one production round, namely:

$$Q_O = \sqrt{\frac{2.D.P.C_s}{(P-D).C_c}} \quad (9)$$

From equation (9) Q we use to find the optimal time intervals at each production round, namely:

$$t_o = \frac{Q_O}{D} \quad (10)$$

To calculate the minimum total cost, Q substituted against Q in equation (7) becomes:

Total inventory costs = storage costs + procurement costs

$$TIC_O = \frac{Q_O(P-D)}{2P}C_c + \frac{D}{Q_O}C_s \quad (11)$$

Data Source

The data used in this study are secondary data. The data taken is in the form of production data, number of requests/ distribution, ordering costs, procurement costs, storage costs, and other data at PT. Perkebunan Nusantara IV (Persero) Medan.

Research Procedure

a. Gather references
b. Retrieve data at PT. Perkebunan Nusantara IV (Persero) Medan
c. Processing data
   After the data is collected then the data is analyzed as follows:
   1) Test the Normality of data with the Normality Test Lilliefors manually.
   2) Calculate the number of economic orders using the EOQ method.
   3) Calculate the optimal production amount by using the EPQ method.
   4) Determine the total minimum inventory cost.
d. Discuss the results
e. Draw a conclusion

3. RESULT AND ANALYSIS

Data obtained based on research conducted at PT. Perkebunan Nusantara IV (Persero) Medan is presented in Table 1 and Table 2.

Table 1. Data on Total Production and Distribution of Crude Palm Oil

No	Month	Production (tons)		Distribution (tons)	
		2017	2018	2017	2018
1.	January	38.348	37.911	38.704,96	42.974,205
2.	February	37.033	37.336	35.354,99	40.904,97
3.	March	47.818	46.311	42.324,23	42.898,235
4.	April	51.406	47.715	50.232,4	50.733,663
5.	May	51.879	51.242	49.743,4	40.674,65
6.	June	45.388	44.147	37.659,15	39.092,63
7.	July	53.467	55.188	37.701,64	34.092,63
8.	August	55.492	51.846	66.963,04	31.324,375
9.	September	47.718	54.038	48.142,07	47.726,691
10.	October	48.320	51.532	45.566,26	70.771,748
11.	November	52.181	46.417	42.186,77	62.447,235
12.	December	50.014	50.167	54.402,3	24.886,312
Total		579.064	573.850	548.981,21	529.348,764

Source: PT. Perkebunan Nusantara IV (Persero) Medan

Table 2. Data on Ordering Costs and Costs for Procurement of Crude Palm Oil

Year	Ordering Cost	Procurement Cost
2017	Rp11.373.056	Rp272.380.253.000
2018	Rp11.099.301	Rp 306.391.533.000

Source: PT. Perkebunan Nusantara IV (Persero) Medan

The cost of storing crude palm oil is 20% of the basic price. The price of crude palm oil in 2017 is Rp8.308,96 and in 2018 is Rp7.357,42.

From the data obtained, the calculation is performed as follows:

a. Test Normality of data with Test Lilliefors
Data were tested using the normality test lilliefors that is data on the amount of crude palm oil distribution. L value is set at the maximum value of the absolute value of the difference F(Z_i) with S(Z). From testing From testing From testing From testing From testing From testing From testing lilliefors lilliefors lilliefors lilliefors lilliefors lilliefors lilliefors These results were obtained in 2017 $L_{hitung} = \max\left[\left|F(Z_i) - S(Z_i)\right|\right] = 0,1492$. And in 2018, $L_{hitung} = \max\left[\left|F(Z_i) - S(Z_i)\right|\right] = 0,2024$. With a real level $\alpha = 0,05$ and n=12 is $L_{\alpha(n)} = L_{(0,05)(12)} = 0,2420$ then it can be seen that $L_{hitung} < L_{tabel}$. For this reason, data on the distribution of crude palm oil is stated to be normally distributed.

b. Determine Economic Orders with the EOQ method
Based on the data that has been obtained, it can be calculated including:
1) Total crude palm oil needs (Years 2017: $D = 548.981,21$ tons and Years 2018: $D = 529.348,764$ tons)
2) Cost of ordering crude palm oil (Years 2017: $S = \text{Rp } 11.373.056$ and Years 2018: $S = \text{Rp } 11.099.301$)
3) Price of crude palm oil per kilogram (Years 2017: Rp 8.308,96 and Years 2018: Rp7.733,301)
4) The cost of storing crude palm oil is based on the cost of the year 2017 and 2018, where the storage cost per kilogram of crude palm oil is 20% of the basic price. (Years 2017: $H = \text{Rp } 1.661.790$ and Years 2018: $H = \text{Rp } 1.471.450$).

The number of economic orders for crude palm oil in 2017 for each message can be completed by:

$$EOQ = \sqrt{\frac{2DS}{H}}$$

$$EOQ = \sqrt{\frac{2(548.981,21)(11.373.056)}{1.661.790}}$$

$$= 2.741,222 \text{ tons/ message}$$

With the required order frequency are:

$$F = \frac{D}{EOQ} = \frac{548.981,21}{2.741,222} = 200,268 \text{ (201 times/year)}$$

Total economical orders for crude palm oil in 2018 for each time a message can be completed by:

$$EOQ = \sqrt{\frac{2DS}{H}}$$

$$EOQ = \sqrt{\frac{2(529.348,764)(11.099.301)}{1.471.450}}$$

$$= 2.825,927 \text{ tons/ message}$$

With the required order frequency are:

$$F = \frac{D}{EOQ} = \frac{529.348,764}{2.825,927} = 187,318 \text{ (188 times/year)}$$

Total cost of crude palm oil inventories in 2017:

$$TIC = \frac{D}{EOQ} \times S + \frac{EOQ}{2} \times H$$
$$= \frac{548.981,21}{2.741,222} \times 11.373.056 + \frac{2.741,222}{2} \times 1.661.790$$
$$= (200,268 \times 11.373.056) + (1.370,611 \times 1.661.790)$$
$$= 2.277.659.179,008 + 2.277.667.653,69$$
$$= 4.555.326.832,698$$

So, the minimum inventory cost for 2017 is Rp 4.555.326.832,698.

Total cost of crude palm oil inventories in 2018:

$$TIC = \frac{D}{EOQ} \times S + \frac{EOQ}{2} \times H$$
$$= \frac{529.348,764}{2.825,927} \times 11.099.301 + \frac{2.825,927}{2} \times 1.471.450$$
$$= (187,318 \times 11.099.301) + (1.412,963 \times 1.471.450)$$
$$= 2.079.098.864,718 + 2.079.104.406,35$$
$$= 4.158.203.270,35$$

So, the minimum inventory cost for 2017 is Rp 4.158.203.270,35.

c. Determine Optimal Production with the EPQ method

Based on the results of data analysis from the company it can be seen that:

1) Average amount of crude palm oil production in 2017 and 2018 every month ($P = 48.038,08$ tons).
2) The average amount of distribution of crude palm oil in 2017 and 2018 per month ($D = 44.930,42$ tons.)
3) The duration of the machine operates for two periods ($t = 22,45$ month).
4) Storage costs for crude palm oil in 2017 and 2018 per ton (C_c = Rp1.566.638).
5) Average procurement costs for crude palm oil in 2017 and 2018 (C_S = Rp24.115.491.083).

The optimal amount of crude palm oil production in 2017 and 2018 can be completed by:

$$Q_o = \sqrt{\frac{2.D.P.C_s}{(P-D).C_c}}$$

$$Q_o = \sqrt{\frac{2(44.930,42)(48.038,08)(24.115.491.083)}{(48.038,08-44.930,42)(1.566.638)}}$$
$$= \sqrt{21.382.085.949,92}$$
$$= 146.226,147 \text{ ton}$$

So, the optimal level of production in each round of production is 146.226,147 tons.

Calculate the minimum palm oil inven tory cost using the formula (2.11):

$$TIC_o = \frac{Q_o(P-D)}{2P} \times C_c + \frac{D}{Q_o} \times C_s$$

$$= \frac{146.226,147(48.038,08 - 44.930,42)}{2(48.038,08)} \times 1.566.638 +$$

$$\frac{44.930,42}{146.226,147} \times 24.115.491.083$$

$$= \frac{146.226,147(3.107,66)}{96.076,16} \times 1.566.638 + 0,3073 \times 24.115.491.083$$

$$TIC_o = \frac{454.421.147,98}{96.076,16} \times 1.566.638 + 7.410.671.971,80$$

$$= 4.729,80 \times 1.566.638 + 7.410.671.971,80$$

$$= 7.409.884.412,4 + 7.410.671.971,80$$

$$= 14.820.556.384,2$$

So, the cost of inventory obtained is Rp14.820.556.384,2 for each month.

So that the minimum costs for each round of production are:

$$TIC_o \times t_0 = 14.820.556.384,2 \times 3,25$$

$$= 48.166.808.248,65$$

Next calculate the number of rounds of crude palm oil production per production cycle in two periods, namely:

a) The number of production rounds in the two periods is:

$$\frac{T}{t_0} = \frac{24}{3,25} = 7,38$$

b) Minimum inventory costs in the two periods are:

$$TIC_o \times t_o \times \frac{T}{t_o} = 48.166.808.248,65 \times 7,38$$

$$= 355.471.044.875,03$$

So, the minimum inventory cost for each period is:

$$TIC_o = \frac{355.471.044.875,03}{2}$$

$$= 177.735.522.437,52$$

So that the minimum inventory cost of crude palm oil obtained each month is equal to:

$$TIC_o = \frac{177.735.522.437,52}{12}$$

$$= 14.811.293.536,46$$

4. CONCLUSION

Based on the calculation of crude palm oil data, the conclusion is that inventory control with the EOQ method can determine economic orders for 2017 amounting to 2.741,222 tons with order frequency 201 times a year and in 2017 amounting to 2.825,927 tons with order frequency 188 times a year. According to the EPQ method can determine the optimal production in 2017 and 2018 amounting to 146.226,147 tons. The total minimum inventory cost according to the 2017 EOQ method is Rp4.555.326.832,690 and in 2018 it is Rp4.158.203.270,35. With the EPQ method the total minimum inventory costs in 2017 and 2018 amounted to Rp177.735.522.432,52.

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