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Implementation Double Exponential Smoothing (DES) Method and Economic Order Quantity(EOQ) Probabilistic Method in Plam Oil Inventory Control

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ABSTRACT

In a company, inventory processing is very important. For this reason, it is necessary to control inventory in order to minimize costs for the benefit of the company. In this study, the authors use the DES method which aims to forecast palm oil demand for 2020 and the Probabilistic EOQ method which can minimize the cost of palm oil inventory at PT. Nusantara IV Medan Plantation. The effectiveness of the Double Exponential Smoothing Method is seen from the minimum MAPE value of 0.29541 which is at an alpha of 0.8. Based on the calculations and data processing carried out, the results of forecasting the demand for palm oil in 2020 were obtained at 483,699,862 Kg with an average demand of 48,369,986 Kg. Based on the Probabilistic EOQ method, the optimal number of orders for palm oil is 8,840,057,829 Kg with an order frequency of 55 times/year with an ROP of 994,798,8395 Kg and the total cost of palm oil inventory is Rp. 79,551,503,603.

Keyword: Double Exponential Smoothing (DES) Method, Economic Order Quantity (EOQ) Method, Inventory.

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1. Introduction

Managing inventory across different industrial sectors is crucial and requires greater attention. This is due to a connection among inventory levels, production timelines, and consumer demand. Consequently, inventory management should be combined with demand predictions, master production timelines, and inventory oversight. Moreover, within the manufacturing system, there are three types of inventory: raw material inventory, semi-finished goods, and finished products [1].

Inventory control models can be categorized into two types: deterministic and probabilistic inventory management. The deterministic model is a type of model that asserts all inventory parameters can be determined with certainty. The probabilistic inventory model serves as an inventory framework utilized when demand or lead time is unpredictable [2].

Forecasting is a procedure conducted when there exists a temporal gap between current data at a specific moment and the data anticipated for the future. Forecasting methods can be categorized into qualitative methods and quantitative methods based on the technique. The approach utilized when there is minimal or no historical data is referred to as the qualitative forecasting method, whereas the approach based on historical data sets to predict future demand is known as quantitative forecasting [3].
The Probabilistic Economic Order Quantity (EOQ) approach calculates the optimal inventory amount that a company should achieve, taking into account the most cost-effective size amid variable demand levels [4].

2. Related Work

2.1 Smoothing Method

In general, forecasting can be viewed as an action performed to anticipate or project a future event in production by utilizing historical data.

In production, forecasting is used to assess the anticipated demand for a product and the initial uniqueness of a planning and control process for production. It can be deduced that the aim of forecasting in production tasks is to minimize uncertainty, allowing for results that are roughly aligned with the real situation.

Forecasting can be classified into three categories, specifically [5] :

1. Short-term forecasting, which is less than 3 months
2. Medium term forecast, i.e. 3 to 18 months
3. Long term forecast, more than 18 months

The methods used for forecasting significantly influence the results produced. Generally, forecasting techniques are categorized into two main types: qualitative forecasting techniques and quantitative forecasting techniques. The smoothing technique is employed to arrange historical data in line with the observed seasonality. This approach is intended for short-term predictions. This approach is categorized into various methods, specifically:

a. Moving average method

The moving average method is used as a forecasting tool in which each period is calculated by ignoring the demand for the earliest period and entering it in the latest period.

b. Exponential smoothing method

The exponential smoothing forecasting method emphasizes the most recent demand and not the previous period's demand.

The Double Exponential Smoothing method is a linear model proposed by Brown and the smoothing process is carried out twice [6].

Forecasting value can be determined based on the following equation:

$$F_{t+m} = a_t + b_t m \quad (1)$$

2.2 The accuracy of the forecast used

MAPE (*Mean Absolute Percentage Error*) or Middle Value Absolute Percentage Error.

$$\text{MAPE} = \frac{\sum_{t=1}^{N} |PE_t|}{N} \quad (2)$$

2.3 Supply

Generally, inventory may also be viewed as raw material inventory, auxiliary supplies, work-in-progress inventory, and completed products [7].

There are 4 types of inventory according to their type, namely:

1. Raw materials are goods purchased from suppliers and will be used or processed into finished products that will be produced by the company.
2. Half-finished materials are raw materials that have been processed or assembled into components but still require further steps to become finished products.
3. Finished Goods are finished goods that have been processed, ready to be stored in finished goods warehouses, sold or distributed to marketing locations.
4. Auxiliary materials (Supplies) are goods needed to support production, but will not be part of the final product produced by the company.

2.4 Decision variables in inventory control

Decision variables in inventory management can be categorized into quantitative and qualitative variables. Quantitatively, the variables that dictate control in the inventory system [8] are as follows:

1. A large number of items to be ordered or made
2. Time of order or manufacture must be done
3. Large quantity of safety stock
4. Inventory control process

Qualitatively, the inventory problems related to the inventory operating system are as follows:

1. Type of goods owned
2. Exactly the item is located
3. A large number of items are being ordered
4. Supplier of each item

2.4 Inventory Purpose

In general terms, the objective of an inventory system is to identify the best solution to all issues related to inventory. Linked to the company's overall goals, the optimal inventory control is frequently evaluated by the highest profit obtained. Measuring the impact of inventory control on overall profit is challenging due to the company's numerous other subsystems beyond inventory. The optimization of inventory management is typically assessed by the lowest overall cost for a specified duration [9].

2.5 Inventory Control Model

In general, the inventory model is divided into two types, namely:

a. Deterministic Model

The deterministic model is characterized by the characteristics of demand and arrival periods that can be known with certainty in advance.

b. Probabilistic Model

The probabilistic model is characterized by the characteristics of demand and the arrival period of orders that are not known with certainty in advance, so it needs to be approached with a probability distribution..

2.6 Probabilistic Economic Order Quantity (EOQ) Method

The Economic Order Quantity (EOQ) approach is a technique that can be utilized to identify the ideal quantity of orders. There are various assumptions applied in managing the supply of the probabilistic EOQ approach, specifically [10] :

1. During the period concerned, both the purchase price and the ordering and storage costs.
2. Leadtime is constant
3. The number of requests in the period is not known with certainty
4. There is no discount in large quantities (quantity discount)

The calculation of inventory control using the Probabilistic EOQ method is carried out with the following formula [11] :

1. Optimum order quantity

$$Q^* = \sqrt{\frac{2DS}{H}} \tag{3}$$

2. Total Safety Stock

$$SS = Z \times \sigma dLT \quad (4)$$

3. Time for re-order point

$$ROP = d \times L + SS \quad (5)$$

4. Order frequency

$$f = \frac{D}{Q^*} \quad (6)$$

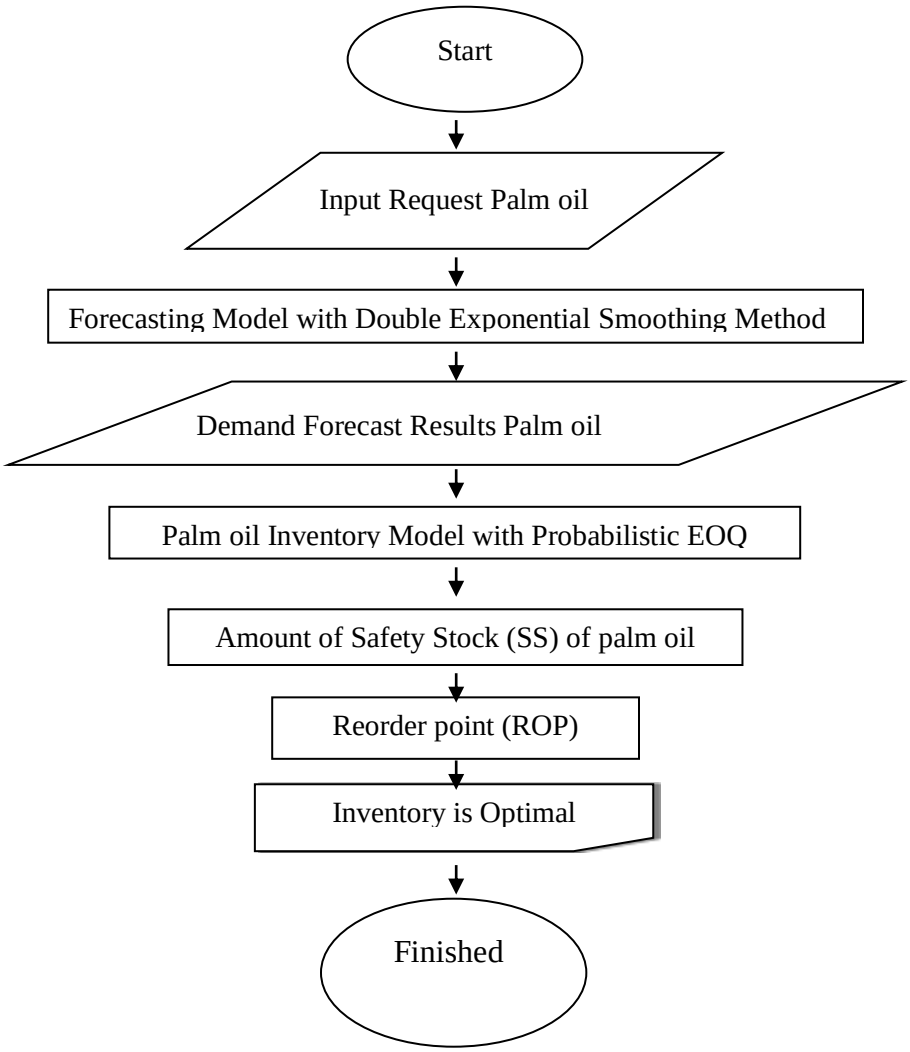
5. Standard Deviation during lead time

$$\sigma dLT = \sigma d.\sqrt{L} \quad (7)$$

6. Total inventory cost

$$TIC^* = \left(\frac{D}{Q^*} \times S\right) + \left(\frac{Q^*}{2} \times H\right) \quad (8)$$

2.7 Flowchart of Double Exponential Smoothing (DES) and Probabilistic EOQ Metode



3. Methodology

The stages in this research are as follows:

1. Collect various reference materials

   In the form of material books obtained in the library and lecture materials, national and international research journals, theses related to the material discussed, articles and so on.

2. Collect existing data at PT. Perkebunan Nusantara IV Medan

   The data collection process will be carried out and collect it for processing to the next stage.

3. Perform data processing

   Data processing is carried out with the following stages:

   a. Forecasting the number of product demands in 2021 using DoubleExponential Smoothing by testing the constant value (α) from 0,1 to 0,9
   b. Calculating the error value from the forecasting results for each constant value using the MAPE (Mean Absolute Percentage Error) method or the Middle Value of Absolute Percentage Error
   c. Determine the economic procurement quantity to produce based on the Probabilistic EOQ Method
   d. Determine the total cost of inventory (total cost) with Probabilistic EOQ

4. Making conclusions and suggestions

4. Result and Discussion

4.1 Data Analysis

The information utilized in this research is obtained from PT. Perkebuana Nusantara IV Medan grounded in dialogues and documented information pertinent to issue resolution. Regarding the outcomes of data gathering received from PT. Nusantara IV Medan Estate, specifically:

Table 1. Total palm oil production in 2019

Month	Total (Kg)
January	38.892.484
February	43.515.008
March	48.392.854
April	49.179.425
May	55.173.127
June	46.548.280

July	54.009.070
August	56.118.200
September	52.767.149
October	54.134.175
November	45.832.197
December	42.144.184
Total	586.706.153

Source: PT. Nusantara IV Plantation Medan

Table 2. Total demand for palm oil in 2019

Month	Total (Kg)
January	37.535.902
February	42.543.758
March	41.262.915
April	42.282.617
May	50.642.413
June	45.556.829
July	53.400.680
August	55.611.852
September	51.669.818
October	53.496.095
November	44.826.762
December	41.596.133
Total	560.425.774

Source: PT. Nusantara IV Plantation Medan

Table 3. Palm oil procurement costs

Year	Procurement Fee (Rp)
2019	Rp.11.001.967.109,111

Source: PT. Nusantara IV Plantation Medan

Table 4. Palm oil storage costs

Year	Storage Fee (Rp)
2019	Rp.8.998,98

Source: PT. Nusantara IV Plantation Medan

Table 5. Palm oil Ordering Fee

Year	Order Fee (Rp)
2019	Rp.8.723.259.370

Source: PT. Nusantara IV Plantation Medan

4.2 Data processing

4.2.1 Demand forecasting with Double Exponential Smoothing

Table 6. Double Exponential Smoothing using =0.8 on the amount of demand for palm oil at PT. Nusantara IV Medan Plantation

t	X_t	S'_t	S''_t	a_t	b_t	F_{t+m}	E	PE
1	37.535.902	37.535.902	37.535.902	-	-	-	-	-
2	42.543.758	41.542.187	40.740.929,84	42.343.443,76	3.205.028	-	-	-
3	41.262.915	41.318.769	41.203.201,46	41.434.337,26	462.271,6	41.896.609	-633.694	-1,535747
4	42.282.617	42.089.847	41.912.518,27	42.267.176,68	709.316,8	42.976.493	-693.876	-1,641044
5	50.642.413	48.931.900	4.752.8023,57	50.335.776,22	561.5505	55.951.282	-5.308.869	-10,48305
6	45.556.829	46.231.843	46.491.079,26	45.972.607,1	-103.6944	44.935.663	621.166	1,363497
7	53.400.680	51.966.913	50.871.745,96	53.062.079,31	438.0667	57.442.746	-4.042.066	-7,569316
8	55.611.852	54.882.864	54.080.640,49	55.685.087,76	320.8895	5.889.392	-3.282.130	-5,901854
9	51.669.818	52312427	52666069,8	51958784,7	-1414571	50544214	1.125.604	2,1784556
10	53.496.095	53.259.361	53.140.703,3	53.378.019,76	474.633,3	53.852.653	-356.558	-0,666512
11	44.826.762	46513282	47838766,14	45187797,64	-5301937	39885861	45.187.797	11,022213
12	41.596.133	42.579.563	43.631.403,5	41.527.722,1	-4.207.363	37.320.359	4.275.774	10,279257
Total								2,9541
Mape								0,29541

From the above calculations, it can be seen that the results of forecasting palm oil demand in 2020 are as follows:

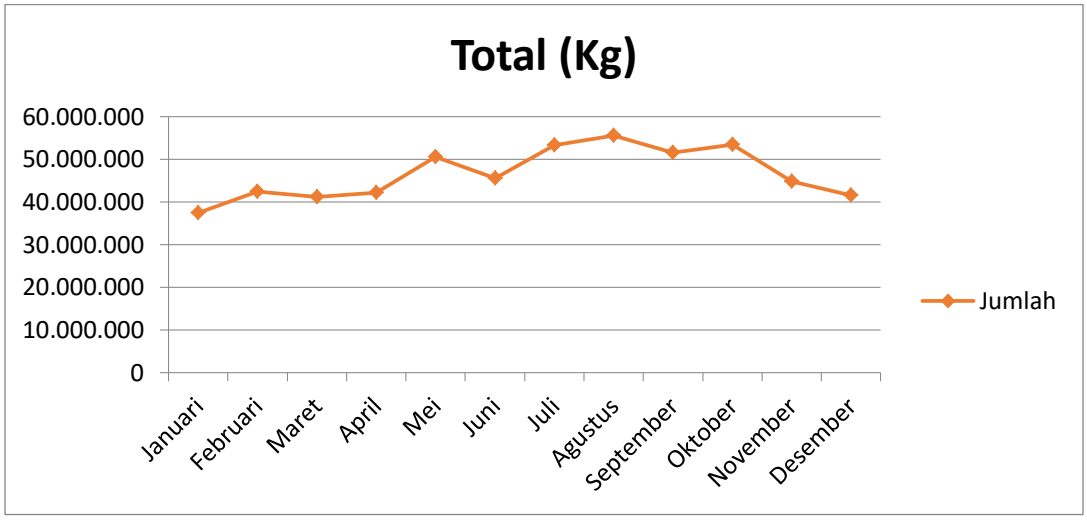


Figure 1. Palm Oil Production Data Plot

4.2.2 Determining the Optimal Order Quantity Using the Probabilistic EOQ Method

1. Total monthly palm oil production is as follows:

$$P = \frac{\text{Production quantity 2019}}{12}$$

$$= \frac{586.706.153}{12}$$

$$= 48.892.179{,}42 \text{ Kg}$$

So it can be concluded that the average amount of palm oil production every month is 48.892.179,42 Kg.

2. The demand for each month based on the results of forecasting with double exponential smoothing is as follows:

$$D = \frac{\text{Number of demand forecasting results 2020}}{10} = \frac{483.699.862}{10}$$

$$= 48.369.986 \text{ Kg}$$

So it can be concluded that the average amount of demand for palm oil every month is 48.369.986 Kg.

3. The average ordering cost (C_0) each month is as follows:

$$C_0 = \frac{\text{Total yearly booking fee 2019}}{12}$$

$$= \frac{8.723.259.370}{12}$$

$$= 726.938.280{,}8$$

So it can be concluded that the average monthly ordering cost is Rp.726.938.280,8.

4. The average cost of procuring production each month is based on the following equation:

$$C_s = \frac{Total\ annual\ procurement\ cost\ 2019}{12}$$

$$= \frac{11.001.967.109{,}11}{12}$$

$$= 916.830.592{,}4$$

So it can be concluded that the average cost of procuring palm oil production every month is Rp.916.830.592,4.

5. The storage cost per kilogram of palm oil based on the equation is as follows:

$$C_c = 20\%(8.998{,}98)$$
$$= (0{,}2)(8.998{,}98)$$
$$= 1.799{,}796$$
$$= \text{Rp}1.799{,}796$$

So it can be concluded that the average storage cost of palm oil per kilogram is Rp. 1.799,796

6. The standard deviation of palm oil based on forecasting results is as follows:

$$S = \frac{\sqrt{\sum_{i=1}^{n}(X_{i-\bar{x}})^2}}{n-1}$$

$$= \frac{483.699.862}{9}$$

$$= 7.903.557{,}6$$

So based on the calculation, it can be concluded that the standard deviation is 7.903.557,6.

7. It is known that PT. Perkebunan Nusantara IV Medan determined the possibility of a shortage of inventory at 5% so that based on the normality table the value of 0,45 was found at z=1,65 or (k=1,65).

8. Standard Deviation during lead time

$$\sigma_L T = \sigma \times \sqrt{L}$$
$$= 7.903.557,6 \times \sqrt{\frac{1}{260}}$$
$$= 490.158,0931$$

Based on the results of the above calculation, the standard deviation during the lead time is 490.158,0931.

9. Optimum order quantity

$$Q^* = \sqrt{\frac{2DS}{H}}$$
$$= \sqrt{\frac{2x483699862x726938280,8}{8998,98}}$$
$$= 8.840.057,829$$

So, the optimal order quantity is 8.840.057,829 Kg

10. Total Safety Stock

$$SS = Z \times \sigma dLT$$
$$= 1,65 \times 490157,8346$$
$$= 808.760,4271$$

Based on the results of the above calculations, it can be seen that the number of Safety Stock is 808.760,4271 Kg.

11. Time for re-order point

$$ROP = d \times L + SS$$
$$= 48.369.986,2 \times 0,003846154 + 808.760,4271$$
$$= 2.999.779,2 + 808.760,4271$$
$$= 994.798,8356$$

Based on the calculation results above, the re-order point time is 994.798,8356 Kg

12. Order frequency

$$f = \frac{D}{Q^*}$$
$$= \frac{483699862}{8840057,829}$$
$$= 54,71682$$

Based on the above calculation, the order frequency is 55 times.

13. Total Inventory Cost (TIC)

$$TIC^* = \left(\frac{D}{Q^*} \times S\right) + \left(\frac{Q^*}{2} \times H\right)$$
$$= \left(\frac{483.699.862}{8.840.057,829} \times 726.938.280,8\right) + \left(\frac{8840057,829}{2} \times 8.998,98\right)$$
$$= 79.551.503.603$$

14. Based on company condition

$$TIC_{per} = (\bar{D} \times H) + (n \times S)$$
$$= (48369986,2 \times 1799,796) + (10 \times 726938280,8)$$
$$= 87.995.948.945 + 72.69.382.808$$
$$= 95.265.331.754$$

4.2.3 The Effectiveness of Double Exponential Smoothing and Probabilistic Economic Order Quantity in Palm Oil Inventory Control

Double Exponential Smoothing method is a method used to predict the optimal level of production in the future based on previous data. This method has the advantage that it has a smoothing process twice so that it minimizes errors in forecasting (Makridaki, 1999)..

It can be concluded that utilizing the double exponential smoothing method for predicting palm oil demand is strongly advised for PTPN 4 Medan, as there is no significant difference between the previous year and the next year, which stands at only 0.7%.

Probabilistic EOQ is a method used to determine the optimal number of orders so as to minimize inventory costs. This method is used when the number of requests for a period is not known with certainty. (Heizer, 2008).

Through data processing and the implementation of the Probabilistic EOQ method, the calculated total inventory cost is Rp. 79.551.503.603 while depending on the company's situation, the overall inventory expense is Rp. of 16.49%. Thus, it can be inferred that the Probabilistic EOQ method's effectiveness in PTPN 4 Medan can reduce the overall inventory cost by 16.49%. Consequently, it is advisable to utilize PTPN 4 Medan for even higher gains.

5. Conclusions and Future Research

5.1 Conclusion

According to the outcomes of the computation and data analysis of palm oil stocks at PT. Perkebunan Nusantara IV Medan menghasilkan kesimpulan dengan menggunakan metode peramalan Double Exponential Smoothing (DES) dan metode Economic Order Quantity Probabilistic:

1. Forecasting palm oil demand in 2020 from March-December using the DES method obtained a total demand of 483.699.862 Kg with an average monthly demand of 48.369.986,2 Kg.
2. Based on the results of calculations with Probabilistic EOQ, the optimal number of orders (Q^*) is 8.840.057,829 Kg each time you order with an order frequency of 55 times with a safety stock of 808.760,4271 Kg with a re-order point (the company makes a reorder)) when inventory is 994.798,8356 Kg .
3. Based on the entire calculation process carried out using the Economic Order Quantity Probabilistic method, it is known that the total cost of palm oil inventory is Rp. 79.551.503.603. Meanwhile, based on the condition of the company, the total inventory cost is 95.265.331.754, it can be concluded that by using the Probabilistic EOQ method, the company will save 15.713.828.151 or 16,49% saving.

5.2 Future Research

According to the research performed, the authors recommend employing software for additional research to ensure the validity of the results achieved.

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