Decision Making of Inventory System Using Monte Carlo Simulation: A Case Study

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Abstract— **Inventory is very crucial role in supporting the operation of the company. Without inventory, the company cannot produce goods anytime and cannot fulfill customer demands. The problem discussed in this research was imbalance of raw material supply. The purpose of this final research was to get the effective control of material with a minimum inventory total cost using Monte Carlo simulation. The result is amount of ordering equal to 1502 kg and reorder point equal to 97 kg with minimum total cost of inventory equal to IDR 2479518**

Keywords- inventory; probabilistic; simulation; monte carlo

I. INTRODUCTION

Inventory plays very important role in supporting operation of the company. Especially in manufacturing and process company, inventory has different forms, values, and levels of importance. Large inventory require large storage area and high storage cost. The value of stored inventories can reach billion of cost.

In the absence of inventory, a company cannot produce goods any time and cannot fulfill customer demand, becausethe material is not always available, so the company will lose the profit and minimize customer satisfaction. The main function of inventory is a buffer, liaison between the production process and distribution to obtain efficiency. Another function of inventory is a price stabilizer against demand fluctuations.

The existence of inventory involvescharges of cost. The cost that related inventory is saving cost, ordering cost, and buying cost. The company has to minimize these cost. The way that can minimize this cost is ordering quantity of material optimally and time to make ordering.

This research discusses about inventory problem at a company in Aceh province, Indonesia. The company is engaged in processing, freezing of fresh fish and ice factory.The products of company have been marketed to consumers both nationally and internationally. The area of product marketing at the national level are Medan, Jakarta, Palembang, and at the international level, one of them is Singapore.

The problems is imbalance of raw material inventory. The raw material is difficult to predict caused by several factors such as traditional fishing boat infrastructure and bad weather. To anticipate the problem, the company needs to plan a proper ordering system of raw materials thereby reducing inventory cost as optimal as possible. If raw materials are ordered in small quantities, it will create a void inventory at a time and it can disrupt the production process. However, if the quantities ordering of raw materials is large, it will certainly lead to high storage costs. Literature of inventory system can see in [1]–[3]

The company has not been able to forecast future request of raw material because the number of request in the future cannot be predicted with certainty, so to minimize the incident can be done by the several method. One of the popular method to forecasting is Monte Carlo (MC) simulation. Literature if this method is [4] and [5]. By using this MC simulation we can measure or predict how much production we must produce in order. Based on this background, the inventory control of fish as raw material isusing MC simulation.

II. METHODOLOGY

The method used in this research is MC simulation. The main object studied is about the stock of fish as raw material. Data needed in this research are secondary data for example fish demand data, storage cost, ordering cost, inventory shortage cost, fish price, and lead time. Data processing is done by setting probability distributions, creating a cumulative probability distribution for each variable, setting random number intervals, generating random numbers and simulating a series of experiments. Then perform the replication and validation tests.

III. RESULT AND DISCUSSION

From Table I it can be seen that 30 times the demand in June 2017 with total demand is 18335 kg and the average demand is 611,167 kg. From the data, 12 time of demand is not zero. Based on Table I we can calculate the range of demand.

TABLE I. DEMAND FROM CUSTOMER

Period	Demand (kg)	Period	Demand (kg)
1	0000	16	100
2	0000	17	0000
3	0000	18	800
4	0000	19	1775
5	0000	20	2560
6	0000	21	0000
7	0000	22	1625
8	0000	23	1050
9	0000	24	0000
10	400	25	0000
11	1425	26	0000
12	3525	27	0000
13	1250	28	0000
14	3400	29	0000
15	425	30	0000

$$R = N_{\max} - N_{\min} \qquad (1)$$

Based on the above calculation using equation (1), the range or range of demand (R) is 3,525 kg. The following is the number of class intervals (k) using equation (2).

$$k = 1 + 33,3 \ \log \ n \qquad (2)$$

Based on the above calculation using equation (2), intervals class (k) is 6. If the amount of data is not too much, as an initial estimate in determining the width of the class, can be used the equation (3).

$$c = \frac{R}{k} \qquad (3)$$

The width of the class (c) based on calculation is 600. Demand based on the class interval and the observation frequency can be seen on Table II.

TABLE II. DEMAND CLASS AND FREQUENCY

Demand (kg)	Median	Frequency
0-600	300	21
601-1.201	901	2
1.202-1.802	1502	4
1.803-2.403	2103	0
2.404-3.004	2704	1
3.005-3.605	3305	2
Total		30

The MC simulation is based on the probability obtained from the historical data of an event and its frequency by distributing the frequency of events divided by the frequency of all events. The calculation of the probability occurrence of demand can be seen at Table III.

The way to convert probability distribution to the cumulative probability for each demand can be accomplished by summing each probability number by the previous amount. Table IV is a cumulative probability distribution table for each variable.

TABLE III. PROBABILITY DISTRIBUTION

Demand (kg)	Frequency	Probability
0-600	21	0,70
601-1201	2	0,07
1202-1802	4	0,13
1803-2403	0	0,00
2404-3004	1	0,03
3005-3605	2	0,07
Total	30	1,00

TABLE IV. COMULATIVE DISTRIBUTION

Demand (kg)	Probability	Cumulative Probability
0-600	0,70	0,70
601-1201	0,07	0,77
1202-1802	0,13	0,90
1803-2403	0,00	0,90
2404-3004	0,03	0,93
3005-3605	0,07	1,00
Total	1,00	

In this study, 10 replications were performed with the combination of demand from random number generator data, and the method used to generate random numbers was by LCG (Linear Congruential Generator) method. The following is the result of generating random numbers based on equation (4). The multiplier factor (α) is 16, adder factor (b) is 4 and the modulus (m) is 125.

$$x_{n+1} = (x_n \cdot \alpha + b) \bmod m \qquad (4)$$

In the Monte Carlo simulation process, conducted for 120 days because it is the safest timeframe in predicting fish stocks. Within 120 days, the system in the company does not change, the status of the company itself is still a developing company so if predicted in 1 year in the fear there will be many system changes in the company that can affect the simulation results so that the model of the simulation cannot be used, but if within 60 days also not too influential to the simulation results. So, by doing a simulation for 120 days it is expected there is no significant system change, because the simulation is very influential on the duration of the forecast so the model can be accepted. The simulation is also done in 10 replication with the combination of demand from random number generator data.

In each replication there is a combination of the point of reorder value. In this study, the simulation point value start from 0 kg up to 200 kg. The value selected because with the limit of the reorder point value of 200 kg, the total inventory cost increasing is inversely proportional.The objective is to obtain the minimum total inventory cost so it is determined 200 kg limit in the simulation. The Q value specified in this study is the number of orders that must be made for each order when the inventory in the warehouse less than equal R. The simulation value of the ordering quantity is 300 kg to 3305 kg with 600 intervals. Input required in MC: saving cost is IDR 8427 per kg, ordering cost is IDR 39 per kg, the price raw material is IDR 14000 per kg and lead time is 5 days. Table V

is a series of MC simulation experiments for 120 days (4 months) with the provisions (1502; 97) meaning that the order is made when inventory is smaller or equal to 97 kg, ordering is 1502 kg.

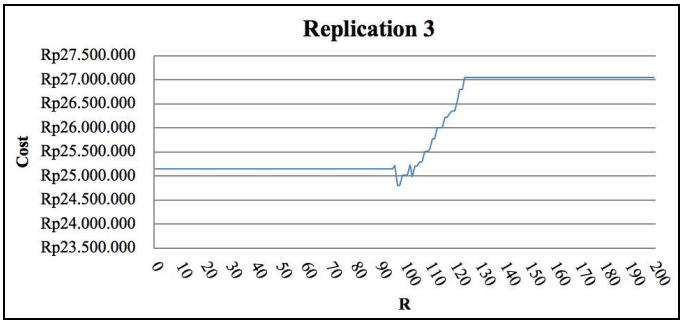

Figure 1. Best plot of replication 3

Figure 1 is best plot of replication 3 where Rp is IDR. Based on simulation, the MC simulation output on replication 3 obtained 1502 kg order amount (*Q*) and 97 of R with total minimum inventory cost of IDR 24.795.518.Based on the overall replication, the average of total cost of fish raw material from *Q* and *R* combination get best result with *Q* parameter equal to 1502 kg and *R* equal to 97. The total inventory cost is IDR 24795518. Simulation result of each replication can be seen in Table V.

TABLE V. SIMULATION OUTPUT EACH REPLICATION

Replication	Output (IDR)
1	29187937
2	28455946
3	24795518
4	26302615
5	25858090
6	25808251
7	25388470
8	27469964
9	26628026
10	27517406
Mean	26741222
Deviation	1395687

Validation of simulation results is done by comparing the company's historical data in July 2017 and the company's simulation results using Mean Absolute Percentage Error (MAPE) method. Equation (5) is the average total inventory cost of the company in July 2017. *TC* is total cost, *SC* is saving cost, *OC* is ordering cost, and *BC* is buying cost. *TC* in July 2017 is IDR 37843226.

$$TC = SC + OC + BC \tag{5}$$

MAPE of simulation result can be calculated using equation (6). Y_t is actual total cost and A_t is total cost of simulation.

$$MAPE = \frac{|Y_t - A_t|}{A} \times 100\% \tag{6}$$

Based on calculation, it can be concluded that the simulation results are valid and can be received satisfactorily because MAPE less than 25%.

IV. CONCLUSION

This research designs MC simulation of inventory at a company in Aceh Province which the amount of demand is probabilistic. MC simulation is using to forecast total cost inventory in future, then make a decision about amount of buying raw material. The average total inventory cost is IDR 24795518. And based on the validation results conducted in July found the total inventory cost of the actual condition of the company is 37843226 and MC simulation results are IDR 30475812. This shows that MC simulation can reduce total inventory cost of the company.

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