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CONTROL OF RAW MATERIALS INVENTORY PROBABILISTIC MODEL USING MONTE CARLO SIMULATION AND DYNAMIC SYSTEM

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ABSTRACT

Increasing efficiency and effectiveness is a fundamental problem for every company. Optimization of raw material inventory is an effort for this problem. PT XYZ is a company engaged in manufacturing various flavors of beverages, one of which is sugar. The level of sugar usage in each month is probabilistic and dynamic. PT XYZ's raw material inventory is determined based on field assumptions, causing a shortage or excess of raw material inventory. This study aims to determine the policy of raw material inventory P backorder model with the integration of Monte Carlo simulation and Dynamic System. The raw material inventory policy is determined based on the order time interval, safety stock, and maximum capacity and compares the actual total inventory cost with the Monte Carlo simulation. Dynamic system simulation is carried out to ensure that the P backorder model inventory policy can be applied. The results showed that the total inventory without Monte Carlo was better than the total cost of the Monte Carlo simulation of Rp198.846.582.98 with an order time interval of 0.30929 years, a maximum inventory capacity of 11149.8 kg and a safety stock of 4335.83 kg. From the results of the comparison using the one sample T-test, it was found that there was no statistical difference between the results of the dynamic system simulation and the results from the calculation of the P backorder model so that the P backorder model policy could be applied to PT XYZ to determine the minimum inventory cost. The results showed that the total inventory without Monte Carlo was better than the total cost of the Monte Carlo simulation of Rp198.846.582.98 with an order time interval of 0.30929 years, a maximum inventory capacity of 11149.8 kg and a safety stock of 4335.83 kg. From the results of the comparison using the one sample T-test, it was found that there was no statistical difference between the results of the dynamic system simulation and the results from the calculation of the P backorder model so that the P backorder model policy could be applied to PT XYZ to determine the minimum inventory cost. The results showed that the total inventory without Monte Carlo was better than the total cost of the Monte Carlo simulation of Rp198.846.582.98 with an order time interval of 0.30929 years, a maximum inventory capacity of 11149.8 kg and a safety stock of 4335.83 kg. From the results of the comparison using the one sample T-test, it was found that there was no statistical difference between the results of the dynamic system simulation and the results from the calculation of the P backorder model so that the P backorder model policy could be applied to PT XYZ to determine the minimum inventory cost.

Keywords: ***Inventory, Raw Material, Model P Backorder, Monte Carlo, Dynamic System***

PRELIMINARY

The smooth production process of a company is influenced by the supply of raw materials. The raw material inventory policies owned by each company vary in quantity and circumstances

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(Ridwan et al., 2018). Inventory of raw materials in many companies is often done without taking into account the planning. This will affect the total cost of raw material inventory (Rufaidah & Fatakh, 2018).

Inventory is an idle resource whose existence is waiting for further processing (Rini & Ananda, 2021). The amount of inventory costs that must be spent to meet consumer needs is a fundamental problem in the industrial sector (Madyana, 2008). The raw material inventory policy must be optimized so that the company can meet consumer demand according to the level of service promised by considering the minimum cost (Sulaiman & Nanda, 2015).

PT XYZ is a company engaged in beverage manufacturing. One of the raw materials is sugar. The level of sugar usage in each month is not fixed. The current sugar procurement process applied by the company is based on field assumptions without using systematic calculations and planning. Inventories of raw materials that do not meet the needs can have an impact on the company's inventory costs.

Based on the existing conditions in the company, a research was conducted that aims to formulate an optimal raw material inventory control based on a backorder probabilistic model by integrating Monte Carlo simulation and dynamic system simulation. Research on the supply of probabilistic backorder raw materials has been carried out (Nursyanti & Syauqi, 2021) in determining the optimum inventory level for primaticol products to determine the total cost of inventory. Research using Monte Carlo simulations has been carried out (Ardiansah et al., 2019) in estimating the supply of tempeh at the Buluk Lupa IKM so that it can provide the right method for carrying out daily production. Ridwan,

Backorder Probabilistic Model

The backorder probabilistic model is the development of a simple probabilistic model in which the service level of the backorder probabilistic model is determined along with the cost optimization. The backorder probabilistic model is used for inventory systems where the order is made based on a fixed time interval (T) but the number of orders is uncertain (Selly Octaviani, 2019).

Monte Carlo Simulation

Monte Carlo simulation is a stochastic simulation whose solution is based on a random process that includes the probability distribution of data variables collected based on historical data and theoretical probability distributions (Ramadan, 2019). Monte Carlo simulations are often used to assess the expected impact of a policy change and the risks associated with the processdecision making (Bunyanuddin, 2018). According to Siregar, et al (2014) Monte Carlo simulation calculations can be done based on the following mathematical models:

1. Determine random value (t)

$$= \{ \frac{2\ \overline{\ln(u)}}{2\ln(1\ )} \} \quad \begin{matrix} < 0.5 \\ 0.5 \end{matrix} \quad \text{..........} (6)$$

2. Determine the ratio of two polynomials in t; p(t) and q(t)

$$(t) = 0.322232431088 + + 0.342242088547\ (t2) + 0.0204231210245\ (t3) + 0.0000453642210148\ (t4) \text{ ....} (7)$$

$$(t) = 0.099348462606 + 0.588581570495\ (t) + 0.531103462366\ (t2) + 0.1035377528\ (t3) + 0.003856070634\ (t4) \text{ ....} (8)$$

3. Calculates the inverse of two polynomials $1(u)$

$$1(u) = \{ \begin{matrix} +^{(t)} \ \overline{(t)} \\ + \ \frac{(t)}{(t)} \end{matrix} \} \quad \begin{matrix} < 0.5 \\ 0.5 \end{matrix} \quad \text{..........} (9)$$

4. Calculating simulation requests (X)

$$= + 1(u) \qquad (10)$$

Dynamic System

The dynamic system is an independent structural modeling that focuses on the intrinsic and dynamic aspects of the system to better understand the problems that occur and improve the behavior of the system based on the system being analyzed. According to Shofa & Widyarto (2018), the stages in dynamic system analysis are: problem identification, dynamic hypothesis , formation of Causal Loop Diagram (CLD), formation of Stock and Flow Diagram (SFD), parameter estimation, model validation, sensitivity analysis, and policy analysis.

RESEARCH METHODS

This research was conducted using a Monte Carlo simulation and a dynamic system in determining the control of raw material inventory with a probabilistic backorder model. The input variables used in the backorder probabilistic model are lead time and fixed time intervals with different order lots. After that, a Monte Carlo simulation and a dynamic system simulation were carried out to determine the influencing factors to minimize the total inventory cost.

The study begins by calculating the average actual demand and the standard deviation of the demand data for the past five years and then determining the parameters to be used, namely the cost of ordering, the price of goods/kg, the cost of storing kg/year, the cost of shortages/kg and the lead time. These parameters are then used to calculate the total cost. Next iteration is done by adding or subtracting the value of the time interval to get the minimum total cost. The iteration is stopped when the total cost is greater than the previous total cost.

The research was continued by generating random numbers for further Monte Carlo simulation. The results of the Monte Carlo simulation request are then used as input to recalculate the minimum total inventory cost of the backorder probabilistic model. The calculation is done repeatedly by adding or subtracting time intervals to get the minimum total cost. The calculation is stopped if the total cost is greater than the previous total cost.

The next stage is done using powersim software to perform dynamic system simulation. This stage is carried out to find out what factors influence inventory and flow. The last stage is to do a one sample t-test validation test on the results of the calculation of the backorder probabilistic model, Monte Carlo simulation and dynamic system simulation to find out whether the model made is correct and logical where the calculation results obtained are not much different from the real conditions.

RESULTS AND DISCUSSION

This study uses data on demand for raw sugar for the past five years along with the required cost components.

Table 1 Data on Sugar Needs per Year

Year	Quantity (kilograms)
2016	15000
2017	17000
2018	19000
2019	22000

2020	25000

Source: PT XYZ

Table 2 Cost ComponentsSugar Needs

Parameter	Notation	Score
Price of goods	P	IDR 9,500/kg
Order Fee	A	IDR 1,500,000/order
Saving Fee	h	IDR 900 kg/year
Shortage Cost	Cu	IDR 9,500/kg
Lead Time	L	0.038 years

Source: PT XYZ

Actual Sugar Demand Scatter Plot Test

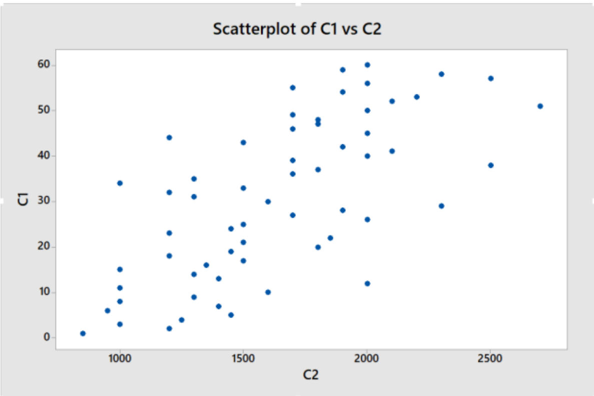

Figure 1 Scatter Plot of Actual Sugar Demand

Figure 1 above shows that the data spreads irregularly on the Y axis and does not converge at a certain point, so the data tends to be homogeneous and unrelated.

Sugar Actual Demand Normality Test

The normality test for the actual sugar demand was carried out using the Kolmogorov-Smirnov test. .

Table 3 Normality Test for Sugar Actual Demand

Year	x	Fn(x)	Z	F(x)	D
2016	15000	0.2	-1,157	0.124	0.076
2017	17000	0.4	-0.654	0.257	0.143
2018	19000	0.6	-0.151	0.440	0.160
2019	22000	0.8	0.604	0.727	0.073
2020	25000	1	1,359	0.913	0.087
mean	: 1960		D	: 0.563	
Standard Deviation	: 3974.92		Conclusion	: normal	

The table above shows that the value of D < Dα where the value of D is 0.076 while and

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the value of Dα is 0.563, so it can be concluded that the sample data for the demand for sugar raw materials is normally distributed.

Backorder Probabilistic Model without Monte Carlo

Table 4 Calculation Results of the Backorder Probabilistic Model without MonteCarlo

Note:	T0	R(kg)	N(kg)	ss(kg)	OT
iteration 0	0.41239	13504.9	45,1128	4670.18	Rp198.717.010.25
iteration 1	0.61859	17869.9	61,924	4993.73	Rp199.526,186.42
iteration 2	0.30929	11149.8	37.9819	4335.83	Rp198.846.582.98
iteration 3	0.15465	7537.35	21.4548	3754.48	Rp201,960,477.97

In the second iteration, the smallest Total Cost (OT) is Rp. 198.846.582.98 with Order Time Interval (T0) 0.30929 years, Maximum Inventory Capacity (R) is 11149.8 kg and Safety Stock (SS) is 4335, 83 kg.

Raw Material Model with Monte Carlo

Table 5 Model Calculation Results withMonte Carlo

No	Simulation (u)	T	p(t)	q(t)	F^{-1}	x
1	0.150810	1.945113	3,713156	4.070779	-1.0330	10894,047
2	0.709633	1.572647	2.821032	2.764811	2.5930	27306.897
3	0.383667	1.384182	2.416465	2.220366	-0.2959	17823.967
4	0.787731	1.760624	3.255635	3.384051	2.7227	32822,427
5	0.890066	2.101370	4.125255	4.717331	2.9759	36828,807

Monte Carlo Simulation Request Validation with Actual Request

Validation of the Monte Carlo simulation request with the actual demand was carried out using the paired two sample t-test in Microsoft Excel.

Table 6 Validation Test Paired Two Sample T-test

	Request current	Request Monte Carlo
mean	1960	25135.22901
Variance	15800000	114203691.3
Observations	5	5
df	4	
t Stat	1.638223121	
P(T<=t) one-tail	0.088358753	
t Critical one-tail	2.131846786	

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P(T<=t) two-tail	0.176717505
t Critical two-tail	2.776445105

Based on table 6 above, it can be seen that the value of t count < t table where t count is 1.6382 while t table is 2.1318 and the P-Value > where P-Value is 0.08 while is 0.05, So it can be said that there is no significant difference between the Monte Carlo simulation request and the actual demand.

Backorder Probabilistic Model with Monte Carlo

Table 7 Results of Backorder Probabilistic Calculations with MonteCarlo

Note:	T0	R(kg)	N(kg)	ss(kg)	OT
iteration 0	0.36416	14656.82	41.4617	4539.37	Rp252.189.750.23
iteration 1	0.54625	19556.86	57.4361	4862.72	Rp253,084,547.32
iteration 2	0.27312	12155.03	31.6724	4325.92	Rp252,360,932.85
iteration 3	0.13656	8053.97	19,2440	3657.37	Rp255,943,691.38

In the second iteration, the smallest Total Cost (OT) is Rp. 252,360,932.85 with Order Time Interval (T0) 0.27312 years, Maximum Inventory Capacity (R) is 12155.03 kg and Safety Stock (SS) is 4325, 92 kgs.

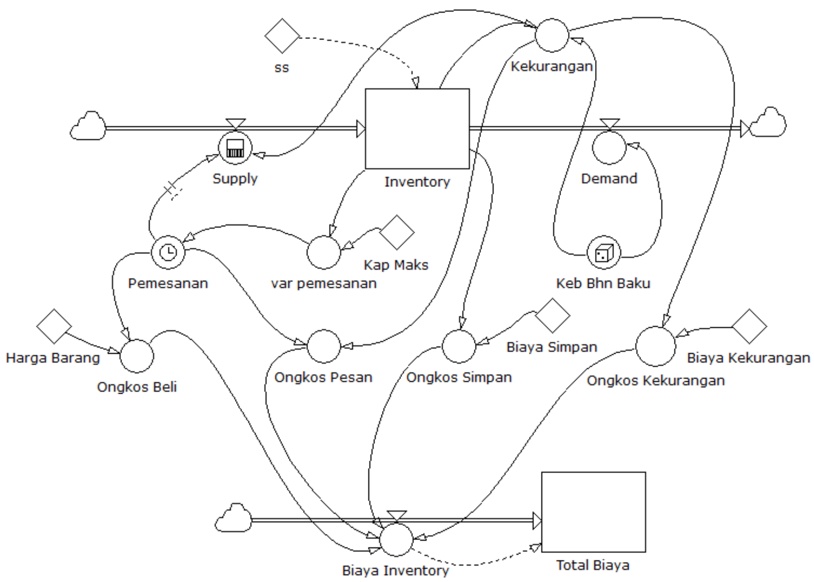

Figure 2 Stock Flow Diagram

Dynamic System Simulation Results

Table 9 Simulation Results of Total Inventory Costs Without Monte Carlo

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No	Cost Simulation Results ntory
1	Rp226,215,764.72
2	Rp222,783,407.60
3	Rp220,163,706.82
4	Rp218,501,264.59
5	Rp.274.439.875.45
6	Rp143,024,436,12
7	Rp.170.693.317.13
8	Rp283,549,864.93
9	Rp201.576.121.39
10	Rp204.234.270.58

Backorder Simulation Probabilistic Validation Test Without Monte Carlo

Table 11 Validation Test One Sample T-Test

Initial Total Cost 198,846,582,984	
Average	216,518,202.9
Stdev	41,997,481.8
n	10
t count	1.331
t table	2,776

Based on the table above shows that the value of t count < t table where t count is 1.331 while t table is 2.776, so it can be concluded that there is no significant difference between the total simulation cost and the initial total cost.

Monte Carlo Simulation Backorder Probabilistic Validation Test

Table 12 Validation Test One Sample T-Test

Initial Total Cost Rp.252,360,933	
Average	203.212.118.8
Stdev	59,909,261.84
n	10
t count	2,594
t table	2,776

Based on the table above, it shows that the value of t count < t table where t count is 2.594 while t table is 2.776, so it can be concluded that there is no significant difference between the total simulation cost and the initial total cost.

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CONCLUSION

Based on the data processing in this study, the results of the actual backorder probabilistic calculation obtained the procurement of raw sugar materials with an order time interval of 0.30929 years, the company's maximum capacity of 11149.8 kg, safety stock of 4335.83 kg and the total procurement cost of Rp. 198. 846,582.98. While the results of the Monte Carlo simulation calculation obtained the procurement of raw materials for sugar with an order time interval of 0.27312 year, the maximum capacity of the company is 12,155.03 kg, safety stock is 4,325.92 kg and the total procurement cost is Rp. 252,360,932.85.

ControlInventories of raw sugar materials at PT XYZ can be determined based on the results of a dynamic system simulation calculation of the total cost of the backorder probabilistic inventory without Monte Carlo because it has a smaller average total cost compared to Monte Carlo, namely the probabilistic backorder of Rp. 216.518.202.9 while in Monte Carlo amounting to Rp203,212.118,8.

DAFTAR PUSTAKA

Ardiansah, I., Pujianto, T., & Perdana, II (2019). Application of Monte Carlo Simulation in Predicting Finished Product Inventory at IKM Buluk Lupa. Journal of the Agricultural Industry, 01(03), 61–69.

Bunyanuddin, A. (2018). Monte Carlo Simulation Model To Determine The Need For Transport And The Cost Of Freight Per Kilogram (A Case Study In A Freight Forwarding Service Company).

Fatma, E., & Pulungan, DS (2018). Inventory Control Analysis Using Probabilistic Method with Backorder Policy and Lost Sales. Journal of Industrial Engineering, 19(1), 38–48.

Madyana, AM (2008). Raw Material Inventory Control with Dynamic System Model (Study on Furniture Company). Journal of Industrial Engineering and Management Systems, 1(2), 15–20.

Nursyanti, Y., & Syauqi, A. (2021). Primaticol Product Inventory Optimization With Back Order Probabilistic Approach. Indonesian Journal of Management and Business, 07(02), 89–104.

Ramadan, H. (2019). Monte Carlo Simulation Approach In Determining The Optimal Solution Of Probabilistic Inventory Costs.

Ridwan, A., Febianti, E., & R, MB (2018). Integration of Monte Carlo Simulation and Dynamic Systems in Formulating a Backorder Model P Raw Material Inventory Policy. Proceedings of the National Seminar on Industrial Engineering, 2, 47–58.

Rini, MW, & Ananda, N. (2021). Probabilistic inventory policy analysis with P-backorder and Q-backorder models. Journal of Industrial Services, 7(1), 1–7.

Rufaidah, A., & Fatakh, A. (2018). Raw Material Inventory Control Analysis Using Economic Order Quantity (EOQ) Method At PT. X. KAIZEN: Management Systems & Industrial Engineering Journal, 1(2), 40–45.

Octaviani, S. (2019). Planning Inventory Of Nylon Powder Raw Material For Coating Process With Probabilistic Method At CV Fachrul Tehnik. (Doctoral dissertation, Polytechnic APP Jakarta).

Shofa, MJ, & Widyarto, WO (2018). Water Resources Model for Industrial and Residential Areas with a Dynamic System Approach. RECAVATION Journal, 6(2), 117–123.

Siregar, L., Herlina, L., & Kulsum. (2014). Raw Material Inventory Control at PT . ABC With Q Back Order Model Using Monte Carlo Simulation. 2(2), 1–7.

Sulaiman, F., & Nanda, N. (2015). Raw Material Inventory Control Using The Eoq Method At Ud. Adi Mabel. Technology, 2(1), 1–11.