System simulation application for determining the size of daily raw material purchases at PT XY

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Abstract. Every manufacturing company needs to implement green production, including PT XY as a marine catchment processing industry in Sumatera Utara Province. The company is engaged in the processing of squid for export purposes. The company's problem relates to the absence of a decision on the daily purchase amount of the squid. The purchase of daily raw materials in varying quantities has caused companies to face the problem of excess raw materials or otherwise the lack of raw materials. The low purchase of raw materials will result in reduced productivity, while large purchases will lead to increased cooling costs for storage of excess raw materials, as well as possible loss of damage raw material. Therefore it is necessary to determine the optimal amount of raw material purchases every day. This can be determined by applying simulation. Application of system simulations can provide the expected optimal amount of raw material purchases.

1. Introduction

Raw material procurement is very important for every manufacturing company. The procurement of perishable raw materials should be done day by day, as in PT XY which is engaged in the processing of sea catch. One kind of raw material processed by this company is squid to produce frozen squid. In this case the company does not specify the amount of daily raw material purchases but receives and pays for the amount of raw materials delivered by the supplier.

The amount of daily raw squid purchases by companies varies from day to day. These variations are related to daily catches that vary according to season and weather. Historically the minimum amount of raw material purchased is less than 2 tons per day and the maximum amount is almost 10 tons per day. While the production capacity needs to be determined and adjusted to the amount of purchase.

The amount of raw squid purchases can cause problems in the procurement of raw materials. This can lead to shortages of raw materials or otherwise excess raw materials to be processed on a daily basis. The low amount of raw material purchases below the level of production capacity will lead to low production. While the high amount of raw material purchases exceeds the production capacity will result in additional cooling costs for storage of excess raw materials. Excessive storage of raw materials over long periods of time will cause worsening quality of squid. Although raw squid can be stored in a freezer, the duration should not last long to avoid damage. Squid that began to suffer damage will not be processed but disposed of as waste. Therefore, the maximum amount of daily
purchases of raw materials and the optimal levels of production capacity should be determined to maximize profits, minimize additional costs and prevent losses. This can be determined by simulation.

System simulation is the process of imitating real events in real systems. Computer simulations with artificial system operations can overcome certain research obstacles and experimental constraints, such as the relatively high cost and longer periods required for real research and experimentation. By applying simulations, the results of research and real experiments that take place in long time intervals can be obtained in seconds in virtual form [1]. Therefore, to overcome real experimental problems, system simulations can be applied to find out the maximum amount of daily raw material purchases and optimal production capacity levels. Simulation system in the form of computer simulation can be done by doing step-by-step process [2].

2. Method
The simulation steps are:
1. Problem formulation. The lack of decision on daily purchasing volume of squid at PT XY Medan, Sumatera Utara.
2. Setting of objectives and overall project plan. The objectives of the simulation is to determine the maximum amount of daily squid purchase which is in accordance with the optimal production capacity.
3. Model conceptualization. Conceptual model of real world system (mathematical and logical relationship concerning the component and the structure of the system). The model was build in the form of a diagram illustrating the relationship between the components used in dynamic simulation.

![Figure 1. The model of the real world system components.](image)

The mathematical models used in system simulation are as follows:
At day \( i \) and production capacity level \( C_j \)
The amount of raw materials in the freezer room: \( F_i = F_{(i-1)} + E_i \)
Daily amount of raw material purchased: \( P_i \)
The amount of raw materials available for processing: \( R_i = F_i + P_i \)
The amount of excess raw material: \( E_i = R_i - C_j \) if \( R_i > C_j \)
The amount of shortage of raw materials: \( D_i = C_j - R_i \) if \( R_i < C_j \)
The amount of production: \( O_i = \begin{cases} C_j \times \text{average rendement} & \text{if } C_j \leq R_i \\ R_i \times \text{average rendement} & \text{if } C_j > R_i \end{cases} \)
The amount of gross profit: \( S_i = O_i \times \text{profit per unit} \)
The total additional cost: \( D_i = E_i \times \text{Freezer cost per unit of RM} \)
The total profit: \( Z_i = S_i - D_i \)
The model of system simulation was build as a discrete dynamic model.
4. Data collection. The data required should be collecting in the format required. Data collection concerning the daily supplied material, production capacity, the selling price of products, production costs, and rendition of production. The amount of daily supplied raw material was supposed as the quantity of daily raw material purchases. The amount of daily supply was collected from historical data in 2 months ago. The data then analyzed statistically. The results of statistical descriptive analysis on daily amount of squid supply within sample size N = 46 are as follows:

\[ \mu = 4.87, \quad \sigma = 2.41, \quad \text{Maximum} = 9.67, \quad \text{Minimum} = 1.55 \]

Pattern of data distribution of raw material supply was tested by using chi square test. The result of chi square test \( \chi^2 \) count = 4.70 and \( \chi^2 \) tables = 9.488 approve that the pattern of amount of daily supply of squid is normal pattern. The value of \( \mu \) and \( \sigma \) are then used as parameter in generating of artificial data of daily amount of squid supply.

The artificial data was generated by use the Excel' sequation of NORMINVERSE() and random number represented the probability. Artificial data of daily amount of supply of squid was prepared per month as shown in Table 1.

| No. | Date (Ton/day) | No. | Date (Ton/Day) |
|-----|----------------|-----|----------------|
| 1   | 04/06 3.00     | 13  | 18/06 6.20     |
| 2   | 05/06 4.80     | 14  | 19/06 2.90     |
| 3   | 06/06 3.20     | 15  | 20/06 7.88     |
| 4   | 07/06 3.70     | 16  | 21/06 4.35     |
| 5   | 08/06 5.50     | 17  | 22/06 5.40     |
| 6   | 09/06 3.20     | 18  | 23/06 9.11     |
| 7   | 11/06 4.40     | 19  | 25/06 5.20     |
| 8   | 12/06 5.80     | 20  | 26/06 1.98     |
| 9   | 13/06 6.00     | 21  | 27/06 4.25     |
| 10  | 14/06 9.10     | 22  | 28/06 9.67     |
| 11  | 15/06 4.60     | 23  | 29/06 6.80     |
| 12  | 16/06 8.80     | 24  | 30/06 2.00     |

5. Model translation. The model of system simulation was build as a discrete dynamic model. The conceptual model was codified into computer recognizable form, as an operational model in worksheet Excel.

6. Verification concerns the operational model. The model which translated and build in form of Excel worksheet was executed by use the artificial data. The results of model execution then compare to the output of real production. The result obtained was vary but the variance was nearly equal to the daily output.

7. Validation that the conceptual model is accurate representation of the real system. Validation is done by compare the result of simulation to total profit on real system. The validation based on statistical analysis of total profit in monthly period.

8. Experimental design. The experiments in the simulation are designed by determining the length of the system operation period, the number of repetitions, and initialization values in the initial stage. The length of the operation period in the simulation is limited to 24 or 25 working days per month. The simulation was run in 10 replicates for each level amount of squid purchase. The maximum amount of daily purchase of squid determined in 7 levels to be compared is set at a rate of 3.5 tons, 4.0 tons, 4.5 tons, 5.0 tons, 5.5 tons 6.0 tons, and as much as supplied by the suppliers per day. The dynamic simulation result of squid purchase is determined and presented in form of total profit per month.
9. Production runs and analysis. The process of system was run and the results then analyzed. The statistical analysis of the acceptance of the simulation results shows that the number of replication $n = 10$ is greater than the minimum number of the required theoretical replication $n = 6$. Thus the average total earnings on each level of daily squid purchase which is obtained by system simulation is acceptable as representing the total earnings of real system.

3. Results And Discussions
The simulation results in the form of monthly total earnings at each level of squid purchases are presented in Table 2 below. Total profit per month is greater at a higher level up to 5 tons per day, and then decreases at the next level. Thus the average expectation of the highest total profit per month is at the maximum level of 5 tons of squid per day, as shown in the graph in Figure 2. According to the maximum amount of this purchase, the optimal production capacity can be determined at 5 tons per day.

Table 2. Expected total profit per month

| Level | (Tons/day) | (Rp.000/month) |
|-------|------------|----------------|
| I     | 3.50       | 414.143        |
| II    | 4.00       | 459.619        |
| III   | 4.50       | 499.970        |
| IV    | 5.00       | 570.046        |
| V     | 5.50       | 401.356        |
| VI    | 6.00       | 369.540        |
| Var   | 8.86       | 295,418        |

Figure 2. Expected total profit per month.

4. Conclusion
Discrete system simulations are run by stochastic processes using probabilistic models. The stochastic dynamic process is used in determining the quantity of squid supply and the stock of raw materials available on an ongoing basis from day to day. System simulation application can provide optimal solution in form of maximum amount of squid purchase every day and optimal production capacity in PT XY. The system simulation result is the average monthly total earnings based on system verification and output validation.

References
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[2] Banks J 1998 Handbook of Simulation John Wiley and Sons