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Inventory Planning and Control in Perishable Items Products Using the Single Order Quantities Method (Case Study: PT XYZ)

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Abstract – **Effective inventory management is crucial for companies distributing perishable products. PT XYZ requires a precise control method to optimize inventory and minimize losses. This study aims to determine the top 5 priority products, identify the best forecasting method with the smallest error and analyze the implementation of Single Order Quantities (SOQ) in inventory management. Using primary and secondary data collected from 1 January 2021 to 4 April 2022, the study employed ABC Analysis to categorize products, followed by demand forecasting using Single Moving Average, Single Exponential Smoothing, and Fuzzy Time Series to select the most accurate method. Inventory planning was then carried out using SOQ to enhance efficiency. Among 196 vegetable types, 5 were identified as the highest priority: Birdseye Chili Pepper (1 kg), Red Cayenne Pepper (1 kg), Birdseye Chili Pepper (Min. 5 kg), Local Cucumber (1 kg), and Bulk Green Paprika. The SOQ method enabled optimized inventory strategies, ensuring product availability while minimizing excess stock. This research provides practical insights for effective inventory planning, particularly for businesses handling perishable goods.**

Keywords - *Demand Planning, Fuzzy Time Series, Inventory Planning, Perishable Product, Single Order Quantity.*

INTRODUCTION

Inventory is essential in a company. When the company does not take an inventory, there are no products to be sold and bought by consumers. Planning and control play an important role in the company's success in achieving their goals as it is one of factors affecting well directed operations at the company. Apart from planning, inventory control is equally important. Control is carried out to ensure that the company's operations are carried out according to the predetermined plan. Inventory planning and control need to be carried out by the company to survive the competition [1–3]. The inventory must be planned and controlled to be able to determine the goods that must be ordered in order to be economical, so when the time is come to reorder those things are done to ensure the availability of the stuffs so that it is more efficient [4–6].

If the product reaches its expiration date before being delivered to the customer, it results not only in a loss due to damaged goods but also a decrease in customer satisfaction. Given the short lifespan of the company’s products, effective inventory control is crucial to minimize both inventory costs and the risks of product spoilage [7], [8]. Perishable items require special handling both in terms of storage, preparation, appearance and maintenance [9], [10].

The high level of competition requires companies to produce high quality products at affordable prices. Therefore, it is necessary to plan and control inventory on PT XYZ’s products in order to meet consumer demands. Since products distributed by PT XYZ are perishable, an inventory system

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optimization is carried out using the Single Order Quantities (SOQ) method.

This study aims to (1) determine the top 5 priority products of PT Agripratama Mitra Sejahtera using ABC Analysis, (2) identify the best forecasting method with the smallest error for inventory planning and control, and (3) analyze the implementation of Single Order Quantities (SOQ) in inventory management for PT Agripratama Mitra Sejahtera.

Single Order Quantity (SOQ) is a method to count the order quantity on short aged item with frequent intervals. The single-order model is concerned with planning and controlling inventory items that have a one-time order opportunity. Items that are ordered at a certain time and used to fulfill demand in that period. The Single Order Quantity model is very suitable for use on products whose demand changes and has a short life cycle such as newspapers, food and bread [11], [12].

METHOD

The first stage, namely, a preliminary study that aims to obtain various information about the research being carried out. The second stage carried out in this study was to identify the problem which aims to explain the problem and make the explanation measurable.

The third stage, namely, is the formulation of the problem to find an answer from data collection and research. In the fourth stage, namely, setting goals from the formulation of the problems that have been carried out. In the fifth stage, namely conducting literature studies from journals and books.

The sixth stage, data collection is then processed using the ABC Analysis, Forecasting, and Single Order Quantity (SOQ) methods. Further analysis of the data obtained in the data processing. And the last is the conclusions and suggestions to provide information about the final results of the research that has been done.

The SOQ approach consists of four types of algorithm models: (1) Constant demand and lead time, (2) Constant demand and variable lead time, (3) Variable demand and constant lead time, and (4) Variable demand and lead time. This research falls into the fourth category because it has non-constant (variable) demand and lead time [13].

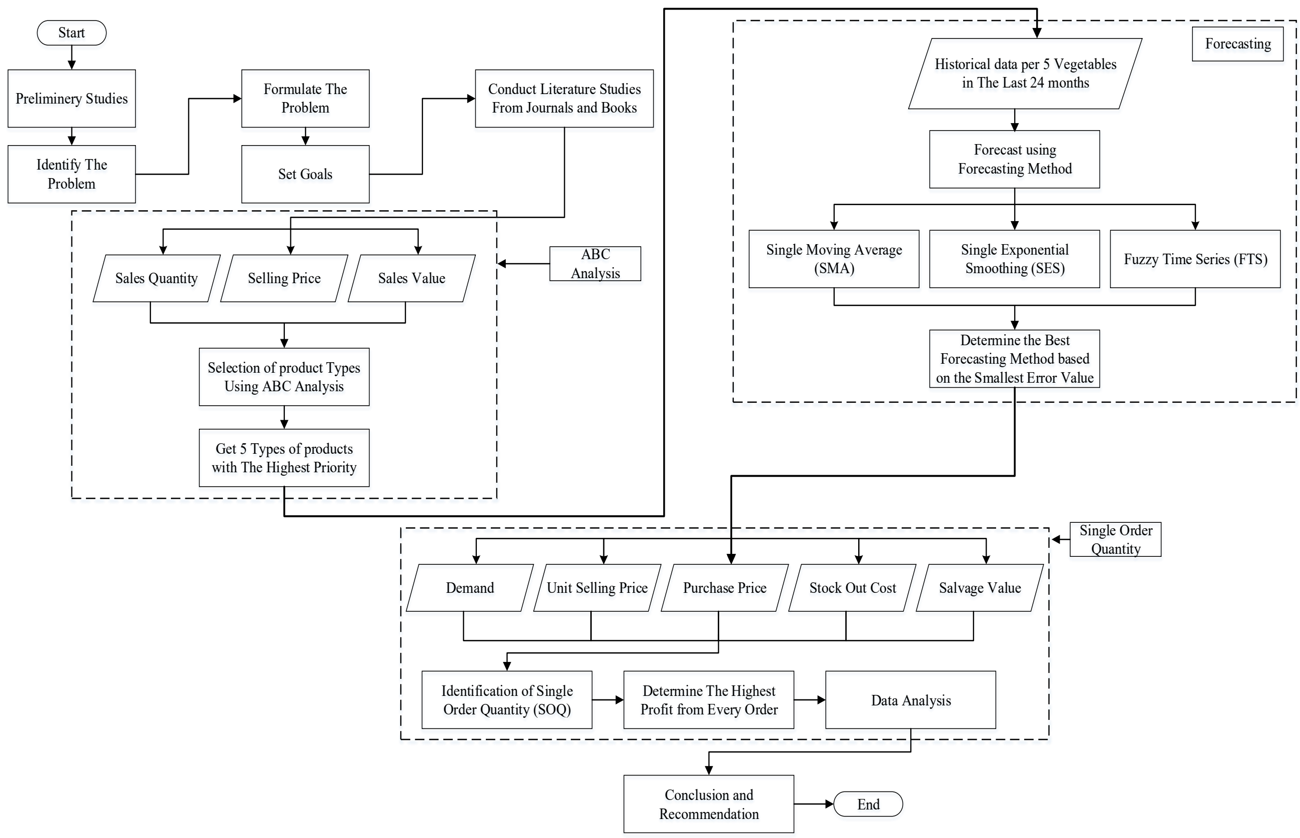

Figure 1. Research Methodology

Decision making under risk involves identifying the demand strategy that yields the highest expected value. For a discrete distribution, the probability that demand will be less than or equal to the single order quantity is taken into account [13].

$$P(M \leq Q) = \sum_{M=0}^{Q} P(M) = 1 - \sum_{M=Q+1}^{M_{max}} P(M) \quad \ldots(1)$$

Where:
Q = single order quantity in units
M = demand in units (a random variable)
$P(M)$ = probability of a demand
M_{max} = maximum demand in units

The probability that the demand will exceed the single order quantity is.

$$P(M > Q) = \sum_{M=Q+1}^{M_{max}} P(M) = 1 - \sum_{M=0}^{Q} P(M) \quad \ldots(2)$$

The expected value of each discrete demand strategy Qi is [13].

$$E(Q_i) = P(M_0)F(Q_iM_j) + P(M_1)F(Q_iM_1) + \cdots + P(M_n)F(Q_iM_n) = \sum_{n=0}^{j} P(M_j)F(Q_iM_j) \quad \ldots(3)$$

Where $F(Q_i,M_j)$ is the outcome of following the demand strategy Q_i when the actual demand is the state of nature M_j. The determination of outcomes can take two forms, depending on whether the amount ordered (Q_i) is less than or greater than the demand level (M_j). When the outcomes are expressed in profit or benefit terms, the following relationship apply [13].

$$F(Q_iM_j) = Q_iJ - (M_j - Q_i)A \; for \; Q_i \leq M_j \quad \ldots(4)$$

$$F(Q_iM_j) = M_iJ - (Q_i - M_j)l \; for \; Q_i > M_j \quad \ldots(5)$$

Equation (4) is for understock conditions, while equation (5) is for overstock conditions.

Where:
A = stockout cost per unit
J = unit profit or benefit
l = less from disposition of unutilized unit
Q_i = single order quantity of l units
M_j = demand level of j units
Q_i-M_j = number of units overstocked
M_j-Q_i = size of stockout in units

When outcomes are expressed in cost or sacrifice terms, the following relationships apply [13].

$$F(Q_iM_j) = Q_iP \; for \; Q_i \geq M_j \quad \ldots(6)$$

$$F(Q_iM_j) = Q_iP + (M_j - Q_i)A \; for \; Q_i < M_j \quad \ldots(7)$$

Equation (6) is for overproduction conditions, while equation (7) is for underproduction conditions.

RESULTS AND DISCUSSIONS

Data Collection

The ABC analysis method initiated with collecting historical demand data. Historical data obtained from PT XYZ was taken from 1 January 2021 to 20 April 2022.

There were 196 items of vegetables sold by PT XYZ, each of which has sales quantity and selling price data record. table 1 shows sales prices at PT XYZ, starting from 1 January 2021 to 20 April 2022. The company's product variation, consisting of 196 items, requires prioritizing products with the highest demand and sales to meet consumer needs and achieve high responsiveness. By prioritizing five key products, the company ensures that fulfilling orders for these products will become its top priority.

Table 1 presents the purchase price, the selling price, the profit obtained from the selling price minus the purchase price, the stockout cost, and the residual value obtained from multiplication between the selling price and the total loss when the item is not sold.

Table 1. Sales Prices

No	Item	Purchase Price (IDR)	Unit Selling Price *(P)* (IDR)	Profit *(J)* (IDR)	Stockout Cost *(A)* (IDR)	Salvage Value *(l)* (IDR)
1	Birdseye Chili Pepper (1 kg)	30,857	80,000	49,143	49,143	16,000
2	Red Cayenne Pepper (1 kg)	110,000	115,000	5,000	5,000	11,500
3	Birdseye Chili Pepper (Min. 5 kg)	29,000	98,000	69,000	69,000	19,600
4	Local Cucumber (1 kg)	10,000	13,000	3,000	3,000	3,900
5	Bulk Green Paprika	22,744	34,000	11,256	11,256	1,700

Data Processing
ABC Analysis

Table 2. ABC Analysis

No	Unit	Item	Sales Quantity	Selling Price (IDR)	Percentage of Sales Value	Classification
1	kg	Birdseye Chili Pepper (1 kg)	5,776	80,000	32.32%	A
2	kg	Red Cayenne Pepper (1 kg)	1,906	115,000	15.33%	A
3	kg	Birdseye Chili Pepper (Min. 5 kg)	1,231	98,000	8.44%	A
4	kg	Local Cucumber (1 kg)	4,926	13,000	4.48%	A
5	kg	Bulk Green Paprika	1,387	34,000	3.30%	A

Cumulative sales value was calculated by addition of a sales value to the cumulative sales value of previous items. Subsequently, sales percentage was calculated by dividing the sales value by the total sales value. The cumulative percentage value and items classification were calculated to determine the class for each item. In the ABC analysis, prioritized items to generate the highest sales sequentially included Birdseye Chili Pepper (1 kg), Red Cayenne Pepper (1 kg), Birdseye Chili Pepper (Min. 5 kg), Local Cucumber (1 kg) and Bulk Green Paprika. It shown in table 2.

ABC classification is a method used to categorize items based on quantity and sales value. In this system, Category A consists of high-value items that exist in limited quantities. Although they make up only about 15-20% of the total items, their contribution to inventory value or company revenue is significantly high, reaching 75-80%. These items are prioritized because they have the greatest financial impact.

Category B includes items of medium value, which are available in larger quantities compared to Category A. Their contribution to revenue is generally lower, around 10-15%, but they still hold considerable importance in inventory management. These products require balanced attention, as they neither demand the highest priority nor can be overlooked.

Category C consists of low-value items that exist in the largest quantity. While their individual financial contribution is small, their frequent usage and high volume make them essential for operations. These items may not require intensive management, but they remain a crucial part of ensuring smooth business processes [4].

Forecasting

Forecasting is done for the month of June because there are several types of vegetables whose sales are discontinued due to several considerations from the company. The error value that exceeds 100% is because the data obtained at the company is not consistent enough.

The data in this study is a type of stationary data. The data obtained at the company has increased and decreased, but the object under study, namely vegetables is harvested at any time and the variance does not change systematically over time or can be called constant. Based on the results of data processing using three forecasting methods, namely Single Moving Average (SMA) [14], [15]; Single Exponential Smoothing (SES) [15], [16] and Fuzzy Time Series [17]–[20]. Three out of five types of vegetables have the smallest error value on Single Exponential Smoothing (SES), this is because Single Exponential Smoothing (SES) is the best method for predicting stationary data types. After all, it is suitable for constant data and produces the smallest error value compared to other methods.

After forecasting the five prioritized vegetables, the smallest deviation value was identified for calculation in the next method, namely Single Order Quantity (SOQ). Based on error values in forecasting, it is noticed that methods resulting in smallest values included the Single Exponential Smoothing (SES) and Fuzzy Time Series (FTS). For Picked Cayenne Pepper (1 kg) the selected method is Single Exponential Smoothing (SES) with an error value of 125.71%, for Red Cayenne Pepper (1 kg) the selected method is Fuzzy Time Series (FTS) with an error value of 27.81%, picked Cayenne Pepper (Min. 5 kg) the selected method is Fuzzy Time Series (FTS) with an error value of 6.40%, Local Cucumber (1 kg) the selected method is Single Exponential Smoothing (SES) with an error value of 72.55 % and Bulk Green Peppers the chosen method is Single Exponential Smoothing (SES) with an error value of 79.92%. From the results of the error values in forecasting, it can be seen that the method that has the smallest value is Single Exponential Smoothing (SES) and Fuzzy Time Series (FTS). The smaller the error value the better because the data will be more valid. The error value in the Fuzzy Time Series (FTS) gets the smallest forecasting value because it uses several iterations.

Single Order Quantity (SOQ)

Single Order Quantity of Red Cayenne pepper (1 kg) table 3 shows demands based on the forecasting results. The number of occurrences was obtained from occurrence-based forecasting. A total of 7 occurrences was obtained from the number of requests. Meanwhile a probability value *(P(M))* of 1 (one) was obtained by dividing the demand by the total demand. The probability on demand > *M* was obtained by dividing the probability *(P(M))* by the number of probabilities *(P(M))*.

In table 4, calculations were carried out when $Q_i \leq M_j$ or understock based on Equation (3) or overstock based on Equation (4). Calculation of the expected value was carried out by multiplying the probability $(P(M_j))$ by the strategy (Q_i). It is showed that there are 3 (three) strategies for the Red Chili Rawit (1 kg) and the strategy that results in the largest expected value is the 230 kg strategy with a profit value of IDR 655,000 [13]. Table 5 shows a recapitulation of item strategies and profit values every three days.

Table 3. Demand of Red Cayenne pepper (1 kg)

Demand (*M*) (kg)	Number of Occurrences	Probability *P(M)*	Probability of Demand > *M*
175	2	0.286	0.714
230	2	0.286	0.429
340	3	0.429	0.000
	7	1.000	

Table 4. SOQ of Red Cayenne Pepper (1 kg)

Strategy (*Q*) (kg)	Probability *P(M)*	0,286	0,286	0,429	Expected Value
	State of Nature *(M)*	175	230	340	
175		IDR 875,000	IDR 600,000	IDR 50,000	IDR 442,857
230		IDR 242,500	IDR 1,150,000	IDR 600,000	IDR 655,000
340		IDR (1,022,500)	IDR (115,000)	IDR 1,700,000	IDR 403,571

Table 5. Strategy Recapitulation on 3 Daily SOQ

No	Item	Strategy	Expected Value
1	Birdseye Chili Pepper (1 kg)	72	IDR 1,777,675
2	Red Cayenne Pepper (1 kg)	23	IDR 65,500
3	Birdseye Chili Pepper (Min. 5 kg)	29	IDR 1,190,494
4	Local Cucumber (1 kg)	57	IDR 11,959
5	Bulk Green Paprika	17	IDR 120,248

CONCLUSIONS

Through the implementation of the ABC Analysis method, followed by forecasting and the Single Order Quantity method, companies can optimize their inventory planning and control. Among the 196 types of vegetables sold by PT XYZ, five were identified as the highest priority, including Birdseye Chili Pepper, Red Cayenne Pepper, Local Cucumber, and Bulk Green Paprika.

To forecast the demand for these priority vegetables, several methods were applied, including the Single Moving Average (SMA), Single Exponential Smoothing (SES), and Fuzzy Time Series (FTS). The best forecasting model for each vegetable was selected based on the smallest Mean Absolute Percentage Error (MAPE) value, ensuring more precise demand predictions. Subsequently, the Single Order Quantity (SOQ) method was used to calculate the optimal purchase strategy for maximizing profits. As a result, Birdseye Chili Pepper (1 kg) yielded the highest profit with a 72 kg ordering strategy, while other vegetables also demonstrated profitable strategies based on demand forecasts.

However, this study has certain limitations. Since the company was recently established, the available data is still limited. Additionally, safety stock calculations have not been incorporated to ensure buffer inventory levels, and there has yet to be development in the field of supply chain sustainability and traceability.

Looking ahead, future research should focus on enhancing data collection to improve forecasting accuracy. Further studies could also explore methods to determine optimal safety stock levels for vegetables, ensuring supply stability. Additionally, advancing research in traceability and sustainability within the supply chain would contribute to a more robust and reliable inventory management system. These improvements will help companies refine their strategies and enhance overall operational efficiency.

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