Reducing Pertamax Inventory Costs at a Gas Station by Eliminating Shortage Using Probabilistic Economic Order Quantity

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Abstract. Gas Station Z is a retail entity selling various fuel products such as gasoline (pertalite, pertamax) and diesel, the demands of which were fluctuating. Such a fluctuating demand often contributed to a condition in which customers failed to get the product at the right time. In addition, the gas station was not prepared with a sufficient safety stock for the fluctuating demand, so the high risk of shortage could not be avoided. The objective of the research was focused on minimizing the costs of product inventory and to avoid the shortage risk by identifying the quantity of the optimum order and setting the right time for re-ordering the product. To achieve the objective, a control model should be utilized. A model to control the inventory, commonly referred to as the Probabilistic Economic Order Quantity was then applied to calculate the quantity of the optimal order. It is very much suitable for use in fluctuating demand conditions and it needs the safety stock calculation to prevent shortage. The data related to demands, lead time, cost of purchase, cost of making order, handling cost, and costs due to shortage were collected using related documents and interviews with the personnel of the gas station. A spreadsheet and Minitab were then utilized to process the data for forecasting the right amount of product order. The amount of products for safety reserve and the time for making a reorder were also calculated. The overall cost of inventory was calculated and compared with the gas station's overall cost of inventory to find out if the model was successful to create the reduction in cost of inventory. The results indicated that the model made it possible for the gas station to lower the cost of inventory to 83.88%.

Keywords: Pertamax Inventory Costs, Eliminating Shortage, Probabilistic Economic Order Quantity.

1 Introduction

Oil fuels are still widely used as primary fuels in Indonesia and the demand of which is increasing from time to time. Based on the data that oil fuels consumption in Indonesia in September 2021 reached 75 million kilo liters [1,2]. It means that the amount showed an increase of 15% compared to the consumption in 2020. It predicted that the consumption keeps increasing in line with the increasing economic activities in the country.

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To meet the need of this big quantity of fuels it is important to apply a reliable supply and stock mechanism as well as good inventory control.

A gas station (hereinafter referred to as the company) is a facility that sells fuels including gasolines and diesels to end customers. The supply of the products in a gas station needs to be well managed and controlled so that the gas station could operate well to reach its highest efficiency level. With respect to the supply of one of the products, it should be noted that the supply should be in accordance with demand. Too much supply of the product would generate inefficiency in inventory cost, whereas shortage in supply would contribute to the loss of business opportunity from customers who go elsewhere to make purchases, the loss of the margin on sales that were not completed, and shipping costs to acquire the product that is not in stock. Therefore, the supply and demand should be well analysed. The commonly analysis for this purpose is Economic Order Quantity method [3-6]. Economic Order Quantity is the quantity of order that could lower the total cost of holding the products and that of making an order in the management of inventory.

Pertamax as one of the fuel products sold in the gas station needs to be controlled appropriately in terms of its inventory. The fluctuating demand for that product in one year energizes the gas station to determine the safety stock in order to lower the probability of the product shortage [7]. The company decided to set its service level to 95%. Therefore, it is important that it calculate the safety stock of the product. This relatively high service level dictates the company to provide sufficient safety stock. Sufficient safety stock would prevent the company from the loss of opportunity for the product sale from potential buyers who might move to other providers for the same product. The risk related to such product shortage was also contributed to by the fact that the demand was fluctuating or probabilistic.

The possibility of unavailability of safety stock and fluctuating demand has generated a risk of a decrease in the company [8]. It is advisable that the company make use of the right inventory control model in the condition in which shortage is apparent attributed to the unavailability of safety stock as well as fluctuating demands. Such a control model that is necessary to apply this condition is the Probabilistic Economic Order Quantity (Probabilistic EOQ). This model recommends that a company provide sufficient safety stock to minimize the product shortage risk and pinpoint the demands that tend to go up and down. By using this kind of model, a company will be able to set the reorder point, the optimum amount for product order as well as the possibility of product unavailability. This is done by identifying the safety stock quantity. The probabilistic inventory control model pays special attention to the high priority in safety stock. This holds true because of the situations in which it is difficult to predict the coming demand and lead time. This conditions potentially create some negative effects that might hinder the company's success to achieve its service level.

The availability of inventory is commonly referred to as an idle resource. The products are there in the storage waiting for a purchase. Storing products in a warehouse bears a certain amount of cost. That is why the inventory in the company should be carefully controlled [9]. It is important to guarantee that the company is of a capability of fulfilling demand when it is needed at the right time. A company without inventory

may create shortage that potentially results in inability to satisfy customer needs, however. Therefore, management of inventory is of high importance to apply so that what the customers need could be fulfilled with a minimum inventory cost [10]. Inventory control makes it possible for a company to deal with the inventory effectively and efficiently.

Probabilistic EOQ is believed to be suitable for use in inventory control in a condition that the demands are fluctuating or going up and down. Such a condition is commonly referred to as probabilistic. This model is, by definition, one model used to set the optimum ordered quantity so that the whole costs of inventory can be put to a minimum. Various situations related to fluctuating demands can be well overcome by means of the model, for instance: (i) the demand can be specifically identified, but the lead time is uncertain (ii) the demand cannot be specifically identified, but the lead time is certain, or (iii) the demand as well as the lead time fail to be observed [11].

Probabilistic EOQ has been used as an appropriate inventory control model to handle conditions in which demand and shortage are highly fluctuating [8]. When Probabilistic EOQ is used, a company is required to determine safety stock to minimize potentially negative impact of product unavailability and to predict the demands that are usually going up and down [11]. This model has made it possible for a company to calculate the time for making a reorder, the optimum order amount, and the possibility in which inventory is unavailable [12]. These are some previous relevant studies that used probabilistic EOQ to make it possible for companies to achieve inventory cost reduction.

2 Method

The research was conducted for a period of four months (from April through July 2022) in Gas Station Z. The research was supported with primary and secondary data. They were collected by means of documentation in the gas station as well as interviews with personnel at the gas station, especially the supervisors as well as the accounting staff. Documentation was intended to obtain data such as demand of the product, order quantity, various costs related to the product purchasing and handling, company's service level, and lead time. interviews were conducted to collect information about inventory control implemented in the gas station.

Upon completion of the data collection, then they were analyzed for product demand, lead time, inventory costs including purchasing cost, ordering cost, handling cost, as well as shortage cost. Forecasting of the product demand was then conducted by using Minitab 17 Software.

To perform analyses on the points above, the optimum order quantity (EOQ) should be determined first. The following is the formula of Probabilistic EOQ.

$$EOQ = \sqrt{\frac{2DS}{H}}$$

where:

EOQ = optimum order quantity
D = demand
S = ordering cost per order
H = carrying cost per unit

It is important to note that it is important to determine safety stock in Probabilistic EOQ in order to prevent product shortage. Safety stock is provided to solve the difference in amount of an inventory between predicted demand and actual one, the predicted lead time and the lead time that really occurs, and other occurrences that are not expected to lower the shortage that is possible to happen [7]. Safety stock is calculated using the following formulae.

$$S'd = Sd\ x\ \sqrt{LT} \quad \text{and}$$
$$SS = z\ x\ S'd$$

where:
S'd = lead time sd
Sd= demand sd
LT = lead time
SS= safety stock
z = point from correlation table

Probabilistic EOQ can also be used to set the time for an order to make. It is commonly referred to as a reorder point [7]. The company is recommended to make an order following the reorder point in a prediction that demand comes regularly or continuously. Reorder point (ROP) is determined by using the formula below.

$$ROP = (D \times LT) + z(S'd)$$

where:
D = demand
LT = lead time
z = point from correlation table
S'd = demand sd

The application of such inventory control model is intended to put costs in inventory to a minimum [9]. It is applied in situations in which demand and/or the lead time are difficult to predict. By means of this model, it is possible for preventing shortage. The formula used to calculate total inventory cost (TIC) considering shortage is as follows [7]:

$$TIC = \frac{DS}{Q} + \frac{ICQ}{2} + IC\ SD$$

Whereas the formula for the same purpose without the consideration of safety stock to prevent shortage is as follows [7]:

$$TIC = \frac{DS}{Q} + \frac{ICQ}{2} + IC\ SD + \frac{D}{Q} k\ SD\ E_{(Z)}$$

where:

D = demand
S = purchasing cost
Q = optimum ordered quantity
I = carrying cost
C = inventory value
SD = standard deviation
k = stock cost per unit
$E_{(z)}$ = number of stock out units from integral normal table

3 Result and Discussion

Fig. 1 shows demand of product at gas station during the period of research.

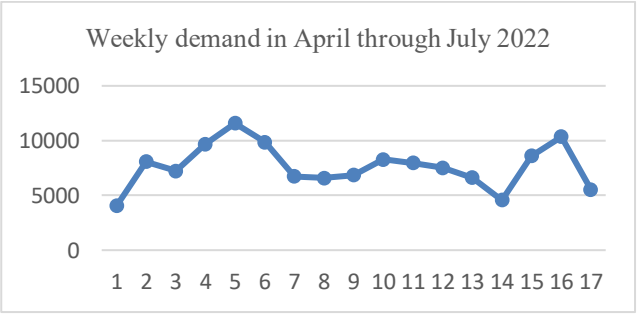

Fig. 1. Weekly Demand of Product in April through July 2022

In Fig.1, it is apparent that the demand of the product was up and down through the time. It was fluctuating. However, the data are stationary in nature based on the result of ACF and Box Cox analyses. Based on the formulae described in the previous discussion, the lead time is approximately two days or 0.06 month. It means that if an order was placed on Monday, the product was expected to arrive two days after that, i.e.; on Wednesday. In one week, the gas station should order the product three times. The holding cost contributed to as much as 28.94% and the shortage cost was estimated to reach IDR 13,700,000 at the time the shortage occurred during the period.

The demand of the product was forecasted to reach 7,205.33 liters per week. It means that the optimum quantity of the product placed in one order was estimated as much as 2,385 liters. This quantity did not consider safety stock to avoid shortage. With the service level of 95% as adopted by the gas station, the safety stock should reach 4,655 liters per period between two orders. With the formula presented in the previous discussion the optimum quantity of the reorder point was 6,713 liters.

The based on the calculation using the formula for total inventory cost without considering safety stock it was obtained that the total inventory cost reached an amount of

IDR 152,825,435. On the other hand, the total inventory cost reached an amount of IDR 24,633,109 when the gas station implemented the policy of safety stock. It is clear here that there was a significant difference between the two total inventory costs, i.e.; IDR 128,192,325 or around 83%.

4 Conclusion

The results of data analysis drive to a conclusion that the weekly product demand is forecast to 7,205 liters. The total inventory cost without shortage (stock out) is IDR 24,632,660, whereas that with shortage is IDR 152,825,435. If the gas station experienced a shortage, the total inventory cost would increase up to 83.882 %. In other words, if the gas station applied the Probabilistic Economic Order Quantity method in controlling its inventory to avoid shortage, it could likely reduce total inventory cost to 83.882%.

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