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Multi-Item Inventory Control Using Economic Order Quantity (EOQ) Model with Safety Stock, Reorder Point, and Maximum Capacity in Retail Business

Muhammad Hanif Mubasysyir[1*], Sudradjat Supian[2], Elis Hertini[3]

[1] *Mathematics Undergraduate Study Program, Faculty of Mathematics and Natural Sciences, Universitas Padjadjaran, Jatinangor, Indonesia*

[2,3] *Department of Mathematics, Faculty of Mathematics and Natural Sciences, Universitas Padjadjaran, Jatinangor, Indonesia*

**Corresponding author email: muhammad18231@mail.unpad.ac.id*

Abstract

The presence of retail businesses in Indonesia has many positive impacts on the community, especially in improving the economy. The existence of buying and selling transactions involving suppliers, retailers, and the community as consumers can play a role in improving the national economy. Retail can be called a bridge for suppliers and consumers to meet their needs. The diversity of consumer needs requires retailers to provide a variety of products from many suppliers. Efforts that need to be made by retail businesses in order to minimize costs incurred are by controlling inventory. To prevent excessive expenditure, the inventory control method used is to apply the Economic Order Quantity (EOQ) model. The EOQ model can provide the optimum total inventory cost by adjusting the frequency of orders placed over a period of time. After obtaining the total inventory cost, the calculation of safety stock, reorder point, and maximum capacity can also be applied so that the inventory costs incurred can be minimal.

Keywords: Inventory control, retails, Economic Order Quantity (EOQ), multi-item

1. Introduction

The existence of traditional retail businesses such as markets or stalls and in more modern forms such as minimarkets and supermarkets in the community has many positive impacts. The existence of buying and selling transactions both in traditional and modern retail can certainly help improve the community and national economy. Based on data from BPS, the number of retail in Indonesia in 2019 consisting of shopping centers and convenience stores was 1,929 units with details of 650 units of shopping centers and 1,279 units of convenience stores.

Inventory control needs to be done by retail entrepreneurs to ensure product availability in accordance with market demand. This can be a system that facilitates business activities, such as providing better customer service, increasing data security related to customers, facilitating and accelerating the process of buying and selling goods, regulating stock availability, and the accuracy of financial data and reports (Heaviside et al., 2020). Inventory storage that is too large can cause storage costs that must be incurred by the company to be greater, such as rental costs, maintenance costs, handling costs, and increased damage and loss costs, as well as the possibility of overcapacity in the storage warehouse. Otherwise, if there is too little inventory, it can cause an increase in shortage costs, stop the production process, and reduce consumer interest. The shortage of inventory causes the order period to increase so that the ordering costs also increase (Yudhanto, 2020).

One of mathematical model that can be used in inventory control is the Economic Order Quantity (EOQ) model. Umami, et al. (2018) stated that the Economic Order Quantity model is the value of the amount of materials needed during each purchase using the most economical cost. The application of the Economic Order Quantity model in the retail business can certainly provide benefits, especially in cost efficiency in providing stock of goods. A variety of goods of various types in retail businesses can be applied to the multi-item EOQ model. In addition to the EOQ model, other methods that can support the application of inventory control so that costs incurred are even more minimum are the calculation of safety stock, reorder points, and maximum capacity.

2. Multi-Item Inventory Control

2.1 Inventory Control

Inventory is a resource that can be in the form of goods or services, which are initially prepared to go through the production process, then stored with certain rules and then will be distributed to consumers through the distribution process. While inventory control is an effort made by the company to minimize the risks that can occur in the production and distribution process. Inventory control is done to reduce the costs that need to be incurred by the company in storing its inventory. In addition, inventory control is also done to maintain storage stability. Inventory that over the capacity will harm the company because the company needs to spend more on capital, maintenance, or damage costs. Otherwise, too little inventory can also casing losses because the intensity of orders will become more often so that the cost of ordering becomes greater, and too little inventory can also result in decreased consumer satisfaction.

2.2 Economic Order Quantity

Inventory control has an important role in supply chain sustainability. In addition, inventory control is the main key for companies to ensure the continuity of a good production process. Several methods have been used by experts to solve inventory problems, one of which is using the Economic Order Quantity (EOQ) model (Utama, 2020). The Economic Order Quantity model is used to make the volume or number of orders match the needs made each order period. By minimizing the cost of ordering goods during the purchase period, ordering costs can be reduced as economically as possible. The Economic Order Quantity model can also be used to minimize the use of raw materials in the production process to be less than the production process without using the EOQ model (Wanti, 2020).

According to Heizer, et al. (2017), the goal of almost all inventory models is to minimize total costs. Assume that important costs such as ordering costs (C_S) and storage costs (C_C) and other costs are constant. Thus, if the sum of C_S and C_C is minimum, then the Total Inventory Cost (TIC) will also be minimum. Based on the cost components mentioned above, Total Inventory Cost, which is cost that must be incurred by the company to finance inventory procurement each planning time period. So the total inventory cost of each planning time period is as follows: (Taha, 2017),

$$TIC = C_B + C_S + C_C + C_P \tag{1}$$

2.2.1 Multi-Item Economic Order Quantity

The EOQ model for multi-item cases or the number of items managed by more than one type is expressed as the following formula: (Bahagia, 2006),

$$TIC = \sum_{i=1}^{n} D_i p_i + \frac{S}{T} + \frac{1}{2}\sum_{i=1}^{n} H_i T D_i \tag{2}$$

The requirement for the minimum total inventory cost is if the time interval between orders and the number of ordering units is optimum, which causes the expenditure of order costs for one period to be optimal. The time interval between ordering period and the optimum number of order units can be calculated using the formula below:

$$T^* = \sqrt{\frac{2S}{\sum_{i=1}^{n} H_i D_i}} \tag{3}$$

$$Q_i^* = D_i\sqrt{\frac{2S}{\sum_{i=1}^{n} H_i D_i}} \tag{4}$$

where

TIC : Total Inventory Cost
D_i : Demand of *i* product
p_i : Price of *i* product per unit
S : Ordering cost per order
H_i : Holding cost of *i* product per unit
T : Time interval between ordering periods
T^* : Optimum time interval between ordering periods
Q_i^* : Optimum number of order units

2.3 Safety Stock (SS)

Safety Stock (SS) is an inventory safety point that aims to prevent companies from experiencing out of stock, delays in the production process at manufacturing companies or delays in the distribution process to consumers due to out of stock. According to Umami, et al. (2018), the calculation of Safety Stock is based on how much the value of deviations that occur against the average demand for goods over a period of time. The deviation value is the standard deviation calculated using the formula:

$$s = \sqrt{\frac{\sum(D_i - \bar{D})^2}{n-1}}$$

From the deviation value obtained through the calculation of standard deviation, the value of safety stock can be calculated using the formula:

$$SS = s \times Z \quad (5)$$

where
s : Standard deviation of product demand
$\bar{D}$: Product demand mean
n : Number of type product
SS : Safety Stock
Z : Safety factor

2.4 Reorder Point

Reorder Point (ROP) is a time when the company must order goods before inventory runs out. According to Wanti, et al. (2020), this reorder point is a period where reservations must be made again. ROP is also related to lead time and safety stock. Because, the point of reordering with the right waiting time is when the safety stock is running low or has almost run out. To calculate the return order point, the formula is used:

$$ROP = (\bar{D} \cdot L) + SS \quad (6)$$

where
ROP : Reorder Point
L : Lead time

2.5 Maximum Capacity (MC)

Maximum Capacity is the maximum storage capacity owned by the company. According to Umami, et al. (2018), maximum capacity is needed so that the amount of inventory stored by the company does not exceed the capacity so that there is no waste of storage costs. To calculate the maximum capacity, the formula is used:

$$MC = SS + Q^* \quad (7)$$

where
MC : Maximum Capacity
Q^* : Total optimum number of order units

3. Results and Discussion

The following is the data used in the study

Table 1: Types of Products

i	Products
1	Arf Kurma Sukari
2	Arf Chickpea Original
3	Arf Golden Raisin
4	Arf Almond Butter

Table 2: Monthly Demand of Each Products during January-December 2022

	Product 1	Product 2	Product 3	Product 4
January	4,017	701	530	506
February	4,243	1,409	881	572
March	11,950	2,818	1,793	973
April	24,897	4,553	1,437	1,502
May	5,460	3,885	1,541	1,131
June	3,289	2,196	894	541
July	5,043	3,445	1,664	826
August	7,834	4,941	2,257	928
September	8,742	4,825	2,793	974
October	10,301	5,781	3,259	808
November	9,154	4,233	2,533	705
December	9,551	3,610	1,952	637
Total	104,481	42,397	21,534	10,103

Table 3: Inventory Costs

	Product 1	Product 2	Product 3	Product 4
p_i (Rp/ons)	7,500	5,000	10,000	20,000
H_i (Rp/ons)	1,875	1,250	2,500	5,000
S (Rp)	100,000			
L	3 Days (0.0082 Year)			

Based on the data above, to get the Total Inventory Cost (TIC), from equation (2) it can be seen that the data needed are D_i, p_i, H_i, S, and T. The data that is not yet known is T. The optimum time interval between orders (T^*) can be calculated using equation (3).

$$T^* = \sqrt{\frac{2S}{\sum_{i=1}^{N} H_i D_i}}$$

$$T^* = \sqrt{\frac{2\times 100{,}000}{(1{,}875\times 104{,}481)+(1{,}250\times 42{,}397)+(2{,}500\times 21{,}534)+ (5{,}000\times 10{,}103}}$$

$T^* = 0.0238$

So the optimum time interval between orders is 0.0238 years or 8 days. Next, substitute the value of T^* into equation (2) with other data previously obtained to get the total minimum inventory cost (TIC) value.

$$TIC = \sum_{i=1}^{N} D_i p_i + \frac{S}{T} + \frac{1}{2}\sum_{i=1}^{N} H_i T D_i$$

$$TIC = ((104{,}481 \times 7{,}500) + (42{,}397 \times 5{,}000) + (21{,}534 \times 10{,}000) +$$

$$(10{,}103 \times 20{,}000)) + \frac{100{,}000}{0.0238} + \frac{1}{2}((1{,}875 \times 0.0238 \times 104{,}481) +$$

$$(1{,}250 \times 0.0238 \times 42{,}397) + (2{,}500 \times 0.0238 \times 21{,}534) +$$

$$(5{,}000 \times 0.0238 \times 10{,}103))$$

$$TIC = 1{,}421{,}397{,}833$$

The minimum total inventory cost obtained using the multi-item EOQ model is Rp1,421,397,833. The optimum number of ordering units (Q_i^*) is calculated for each item product. Since T^* is already known, the optimum number of ordering units for each product $(Q_1^*, \ldots, Q_4^*)$ is calculated using equation (4).

$$Q_i^* = T^* \times D_i$$

For product 1 $(i = 1)$
$Q_1^* = T^* \times D_1$

$Q_1^* = 0.0238 \times 104{,}481$

$Q_1^* = 2486.647 \approx 2487$

For product 2 $(i = 2)$
$Q_2^* = T^* \times D_2$

$Q_2^* = 0.0238 \times 42{,}397$

$Q_2^* = 1009.048 \approx 1010$

For product 3 $(i = 3)$
$Q_3^* = T^* \times D_3$

$Q_3^* = 0.0238 \times 21{,}534$

$Q_3^* = 512.509 \approx 513$

For product 4 $(i = 4)$
$Q_4^* = T^* \times D_4$

$Q_4^* = 0.0238 \times 10103$

$Q_4^* = 240.451 \approx 241$

So the optimum number of ordering units for each product is 2.487 ounces for the 1st product, 1.010 ounces for the 2nd product, 513 ounces for the 3rd product, and 241 ounces for the 4th product. Based on equation (5), safety stock is obtained by multiplying the standard deviation (s) from demand by the safety factor (Z). The steps to calculate the standard deviation from demand are as follows.

$$s = \sqrt{\frac{\sum(D_i - \bar{D})^2}{n-1}}$$

$$s = \sqrt{\frac{(104{,}481 - 44{,}628.75)^2 + (42{,}397 - 44{,}628.75)^2 + (21{,}534 - 44{,}628.75)^2 + (10{,}103 - 44{,}528.75)^2}{3}}$$

$$s = 42{,}081{,}9337$$

So the standard deviation value of demand (s) is 42,081.9337. While the Z value for the 95% service level is 1.64. Then substitute the s and Z values into equation (5) to get the Safety Stock (SS) value.

$$SS = s \times Z$$

$$SS = 42{,}081.9337 \times 1.64$$

$$SS = 69{,}014.3713 \approx 69{,}015$$

The value of safety stock obtained is 69,015 units. Next, the ss value obtained is used to determine the reorder point. Substitute the SS value and other variables into equation (6).

$$ROP = (\bar{D} \times L) + ss$$

$$ROP = (44{,}628.75 \times 0.0082) + 69{,}015$$

$$ROP = 69{,}380.9557 \approx 69{,}381$$

So the reorder point is obtained when the inventory reached 69.381 units. Next, to calculate the maximum capacity of storage, use equation (7).

$$MC = ss + Q^*$$

$$MC = 69{,}015 + 4{,}248.657$$

$$MC = 73{,}263.657 \approx 73{,}264$$

The maximum capacity for related products is as much as 73.264 units.

Table 4: Total Inventory Cost Comparison

	Without Using EOQ Model	Using Multi-Item EOQ Model
T	4 days	8 days
TIC	Rp1,426,992,500	Rp1,421,397,833

It can be seen in Table 4.4 that the time interval between orders applied by Bursa Sajadah retail stores is still not optimal because the smaller the time interval between orders, the more often orders will be made which results in increased costs. The costs that need to be incurred by the company if it does not apply the multi-item EOQ model are Rp1,426,992,500, while if the multi-item EOQ model applied, the costs that need to be incurred are Rp1,421,397,833. There is an expenditure difference of Rp5,594,667 which shows that the application of the multi-item EOQ model can minimize inventory costs.

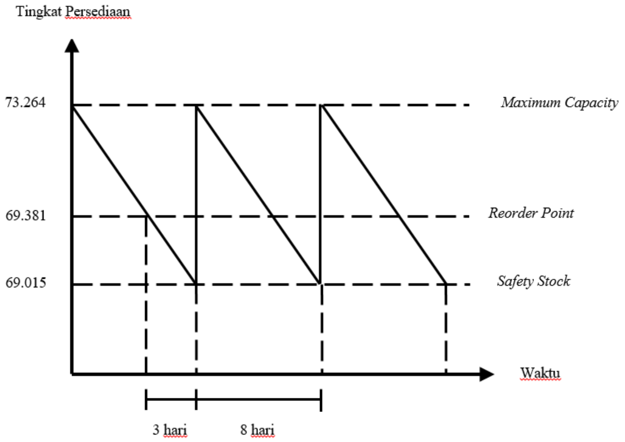

Figure 1: Analysis Result of Multi-Item EOQ Model Application

4. Conclusion

Based on the results of the calculation above, it can be concluded that the application of the multi-item EOQ model in the retail business can produce a minimum total inventory cost caused by an optimal time interval between orders, which is eight days, with a difference in total inventory costs of Rp5,594,667. Bursa Sajadah retail stores can also set other calculation results, such as safety stock of 69,015 units, reorder point at 69,381 units, and a maximum capacity of 73,264 units to be applied in the company to keep from incurring unnecessary costs.

References

Bahagia, S. (2006) *Sistem Inventori*. Bandung: Penerbit ITB.

Heaviside, M., Mulyawan, B., Sutrisno, T. (2020). 'Determination of minimum stock on system retail using forecast, economic order quantity and reorder point methods', *IOP Conference Series: Materials Science and Engineering* 1007 012180.

Heizer, J., Render, B., dan Munson, C. (2017) *Operations Management: Sustainability and Supply Chain Management*. 12th edn. Pearson Education, Inc

Taha, H. (2017) *Operation Research: An Introduction*. 10th edn. Harlow: Pearson Education Limited

Umami, D., Mu'tamar, F., Rakhmawati (2018) 'Analisis Efisiensi Biaya Persediaan Menggunakan Metode EOQ (*Economic Order Quantity*) pada PT. XYZ', *Jurnal Agroteknologi*, 64-70.

Utama, D., Widodo, D., Ibrahim, F., Hidayat, K., dan Dewi, S. (2020) 'The Sustainable Economic Order Quantity Model: A Model Consider Transportation, Warehouse, Emission Carbon Costs, and Capacity Limits', *Journal of Physics: Conference Series* 1569 022095.

Wanti, L., Maharrani, R., Prasetya, N., Tripustikasari, E., dan Ikhtiagung, G. (2020) 'Optimation Economic Order Quantity Method for a Support System Reorder Point Stock', *International Journal of Electrical and Computer Engineering (IJECE)* Vol. 10, 4992-5000.

Yudhanto, N., Arifah, Hutauruk, P., dan Indriyati (2020) 'Calculation of EOQ (Economic Order Quantity) in Optimizing the Inventory Level of Dacron at Mell Toys Home Industry', *Journal of Physics: Conference Series* 1573 012036.