Multi-item Inventory Modeling for Generic Drug Inventory Control Planning

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Abstract. A pharmacy does not only manage or sell one type of generic drug but several types of drugs that have dependencies such as the same source of obtaining goods so that a model for multi-item inventory is needed. The purpose of this study is to build a multi-item inventory model for generic drug inventory control planning in pharmacies so as to produce an optimal inventory control planning decision using the heuristic method. The type of data used is secondary data. The conclusion of this research is model formation starts from the total inventory cost to get the ordering time and economic order lot. The economic order lot is greatly influenced by the number of orders, where the same number of orders will result in the same economic order lot.

Keywords: multi-item generic drug, pharmacy

1 Introduction

Inventory in a business unit is one of the important things to ensure the sustainability of a business. Therefore, inventory planning is needed [1]-[2] so that consumer demand can be met. This planning is needed not only to meet consumer demand but also in terms of cost and the validity period of a product. Inventory can be seen as an asset, but on the other hand it can be considered a burden on a business because of the costs required to maintain the inventory. One of the important issues in inventory is the management of pharmaceutical items such as medicines. Medicine is one of the primary needs needed for healing and rehabilitation of diseases in order to improve the level of welfare. Inventory management of medicines is absolutely necessary for business units that provide medicines. It is important for drug providers such as pharmacies to plan policies related to the supply of medicines so that the availability of medicines is optimal. Accumulation of drugs will cause losses because drugs have an expiration date, while a shortage of drug supplies will cause consumers to switch to other places. One type

SICBAS 2023, November 03, Palembang, Indonesia

DOI 10.4108/eai.3-11-2023.2347898

of drug that is widely used is generic drugs [3]–[6] because the price is relatively cheap but has relatively the same effect as patent drugs.

A pharmacy does not only manage or sell one type of generic drug but several kinds of drugs that have dependencies such as the same source to obtain goods so that a model for multi-item inventory is needed. Multi-item inventory models are developed based on various problems such as lot-sizing problem with supplier selection [7], gradual arrival of suppliers [8], discount [9]–[11], deterioration and partial backlogging [12]. Solving inventory problems can be done using exact methods such as First in First Out FIFO (FIFO) atau *First Expired First Out* (FEFO) [13]-[14] and heuristic methods such as silver meal [15]-[16], Wilson [17], *Economic Part Period* (EPP) dan metode *Part Period Balancing* (PPB) [18]–[20].

In this study, a multi-item inventory model was built to determine the optimal ordering time and ordering lot for generic drugs in pharmacies using the heuristic method. Thus, pharmacies can optimize generic drug inventory in order to meet consumer needs and minimize the risk of drug accumulation which makes operating costs increase

2 Literature Review

In determining inventory policy there are two specific problems [21]:

a. When the order is placed.
b. How many items will be ordered for each order.

The assumptions used are:

a. Demand for goods over the ordering horizon is known with certainty and will come continuously over time at a constant rate.
b. The order lot size is fixed for each order.
c. Lead time is zero
d. The price of goods ordered is independent of the quantity of goods ordered or purchased and the time of day.

3 Methodology

The solution steps are:

a. Variable definition
   This step is done to make it easier to find the relationship between one variable and another
b. Determination of total inventory cost
   This step is done to get the total cost of the elements that affect inventory costs, namely purchasing costs, ordering costs, and storage costs.
c. Determination of the period between orders and the economic ordering lot size for item i
   This is done by differentiating the total cost function so that the total cost is minimal

d. Determination of optimal order quantity is obtained by substituting the results in Step c to the order quantity function.

4 Result and Discussion

4.1 Variable Definition

For modelling purposes, the definition of the variables used is first given.

O_T : total cost
O_s : storage cost
O_b : purchase cost of goods
O_p : order cost
D_i : demand for good i for a planning horizon (unit/period)
p_i : price of good i per unit
I : percentage of the cost of storing goods per period to the price of goods
h_i : cost of storing item i per unit per period
A : order cost for each order.
L_i : lead time of item i
q_i : economic ordering lot size for item i
T : period between orders
N : number of items of goods

4.2 Model Formulations

Modelling begins by determining the total inventory cost, which is the sum of all costs.

$$O_T = O_b + O_p + O_s = \sum_{i=1}^{N} D_i p_i + \frac{A}{T} + \frac{1}{2}\sum_{i=1}^{N} h_i q_i \tag{1}$$

Equation (1) states that total cost is influenced by demand, price, order cost, period, and storage cost

Based on Equations (1) the variables T and q_i are then determined, namely

$$T = \frac{q_i}{D_i} \text{ so that } q_i = TD_i \tag{2}$$

Equation (2) ensures that variables T and q_i are not independent variables

By substituting q_i in Equation (2) into Equation (1), we obtain

$$O_T = \sum_{i=1}^{N} D_i p_i + \frac{A}{T} + \frac{1}{2}\sum_{i=1}^{N} h_i T D_i \tag{3}$$

The condition for obtaining minimum O_T are

$$\frac{\partial O_T}{\partial T} = 0$$

$$-\frac{A}{T^2}+\frac{1}{2}\sum_{i=1}^{N}h_i D_i = 0$$

$$T^2 = \frac{2A}{\sum_{i=1}^{N}h_i D_i}$$

$$T^* = \sqrt{\frac{2A}{\sum_{i=1}^{N}h_i D_i}} \tag{4}$$

Equation (4) states the time when the order is placed

Substituting Equation (4) into Equation (2), we obtain

$$q_i^* = D_i\sqrt{\frac{2A}{\sum_{i=1}^{N}h_i D_i}} \tag{5}$$

Equation (5) states the economic ordering for each item of goods

4.3 Application of the Model to Generic Drug

This study uses data on the most ordered generic drugs at Pharmacy X in Palembang City, Indonesia as shown in the Table 1.

Table 1. Inventory of generic drug

Generic drug	Requirement (units/month)	Price (IDR/unit)
Amoxicillin 500 mg caplet	500	500
Clindamycil 150 mg capsule	300	700
Ambroxol tablet	300	130
Simvastatin 10 mg tablet	300	200
Simvastatin 20 mg tablet	300	250
Salbutamol 2 mg tablet	300	140
Salbutamol 4 mg tablet	300	160
Methylprednisolone 4 mg	300	175
Acetylsisteine	300	120
Amlodipine 5 mg	300	175
Amlodipine 10 mg	300	470
Mefenamic acid 500 mg	500	350

where each order costs IDR 150,000. Table 1 shows the 12 most ordered generic drugs per month, which are more than or equal to 300 units with a price per unit of IDR 120 to 700.

Furthermore, based on Equation (4), T^* is calculated as follows

$$T^* = \sqrt{\frac{2x150{,}000}{500x500+300x700+300x130+\cdots+500x350}} = 0.504$$

Because the value of T^*has been obtained, to find the value of economic order lot (q_i) for each drug, we can use Equation (2) as follows

For amoxicillin 500 mg caplet :

$$q_1 = 0.504x500 = 252$$

For clindamycil 150 mg capsule

$$q_2 = 0.504x300 = 151$$

For ambroxol tabel:

$$q_3 = 0.504x300 = 151$$

Calculations for other drugs were done in the same way. The complete calculation results are presented in Table 2.

Table 2. Economical ordering lot of generic drugs

Generic drug	Economic order lot
Amoxicillin 500 mg caplet	252
Clindamycil 150 mg capsule	151
Ambroxol tablet	151
Simvastatin 10 mg tablet	151
Simvastatin 20 mg tablet	151
Salbutamol 2 mg tablet	151
Salbutamol 4 mg tablet	151
Methylprednisolone 4 mg	151
Acetylsisteine	151
Amlodipine 5 mg	151
Amlodipine 10 mg	151
Mefenamic acid 500 mg	252
Total	2,014

Table 2 shows that generic drugs ordered as many as 500 units per month obtained an economic lot value of 252, while for generic drugs ordered as many as 300 units per month obtained an economic lot value of 151. Average order lot is 2,014/12=167 units.

Thus, the order is placed when 0.504 months or 15 days with an average order lot of 167 units.

5 Conclusion

Based on the discussion, the formation of the model starts from the total inventory cost to get the ordering time and economic ordering lot. The economic order lot is greatly influenced by the number of orders, where the same number of orders will result in the same economic order lot. In this generic drug data, the ordering time is 0.5 months with an average economic ordering lot of 167 units.

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