Optimising Inventory Control in Pharmaceutical Distribution: A Case Study on PT. XYZ

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Abstrak

Pengendalian persediaan merupakan kebijakan yang dirancang untuk mengatur pasokan, penyimpanan, dan ketersediaan barang dalam organisasi. Tujuan utamanya adalah memastikan stok selalu cukup untuk memenuhi permintaan sekaligus meminimalkan biaya penyimpanan. PT XYZ, yang merupakan distributor farmasi, menghadapi kendala dalam mengoptimalkan kebijakan persediaannya sehingga sering terjadi stockout, overstock, serta kerusakan produk selama distribusi. Penelitian ini bertujuan merancang kebijakan persediaan yang optimal guna meningkatkan kinerja sistem persediaan obat perusahaan. Tahapan penelitian dimulai dengan klasifikasi item menggunakan metode ABC serta perhitungan Turnover Ratio (TOR). Selanjutnya, scatter diagram dibuat berdasarkan data historis permintaan untuk mengidentifikasi pola permintaan produk. Kemudian, dilakukan peramalan permintaan dengan tiga metode berbeda, dan metode paling akurat dipilih berdasarkan Mean Absolute Percentage Error (MAPE). Permasalahan persediaan dikategorikan, di mana obat kelas A dikelola menggunakan model Q, sedangkan kelas B dan C menggunakan model P. Metode Hadley-Within dengan backorder digunakan sebagai pendekatan penyelesaian. Hasil penelitian menunjukkan bahwa kebijakan usulan menghasilkan biaya persediaan total sebesar Rp339.221.858,00 dengan TOR 4,26. Sebaliknya, sistem yang saat ini digunakan menimbulkan biaya sebesar Rp1.338.286.901,00 dengan TOR 8,7. Implementasi kebijakan yang diusulkan dapat menurunkan biaya hingga 74,65% atau Rp999.065.044,00 serta meningkatkan efisiensi persediaan. Penelitian ini menawarkan pendekatan praktis bagi distributor farmasi untuk meningkatkan manajemen persediaan, menekan biaya, dan mengoptimalkan kinerja rantai pasok.

__Kata kunci__: Hadley-Within, MAPE, metode ABC, pengendalian persediaan, produk farmasi.

Abstract

Inventory control is a policy designed to manage and regulate the supply, storage, and accessibility of items in an organisation. Its primary purpose is to ensure that there is always enough stock on hand to meet demand while minimising the costs associated with holding and maintaining inventory. XYZ, a pharmaceutical distributor, faces challenges in optimising its inventory control policy, resulting in frequent stockouts, overstocks, and product damage during distribution. This study aims to design an optimised inventory control policy to enhance the Company's drug inventory system performance. The research begins by classifying inventory items using the ABC method and calculating the inventory turnover ratio (TOR). A scatter diagram is then constructed based on historical demand data to identify product demand patterns. Subsequently, three forecasting methods are applied, and the most accurate method is selected based on the Mean Absolute Percentage Error (MAPE). Inventory issues are categorised, with Class A drugs managed using the Q model and Classes B and C using the P model. The Hadley-Within method with backorder is employed for inventory problem-solving. The proposed inventory policy results in a total inventory cost of IDR 339,221,858 and a TOR of 4.26. In contrast, the existing system incurs a total inventory cost of IDR 1,338,286,901 with a TOR of 8.7. Implementing the optimised policy would lead to a cost reduction of 74.65%, equating to IDR 999,065,044, and improved inventory efficiency. This study provides a practical approach for pharmaceutical distributors to enhance inventory management, reduce costs, and optimise supply chain performance.

__Keywords__: ABC Method, Inventory control, Hadley-Within, MAPE, pharmaceutical products

1. Introduction

Improvement of service is important and must be continuously done by the Company so that customer satisfaction is still met. The level of service can be achieved by fulfilling the demand target, which can be accomplished through proper inventory control planning. Effective inventory control is crucial for every Company to implement and understand, as it enables the control of sudden stockouts that occur when customers request more or excess goods, thereby reducing the risk of loss.

Inventory is an idle resource or an item that is stored for a certain period and used for a future period (Freeland, 2008). The reason for this inventory is due to uncertainty, particularly regarding lead times and demand quantities,

which prevents the Company from providing goods on time, in the right place, and in the desired quantity. According to Monden (1983), as an idle resource, the existence of inventory can be seen as waste, and this means a burden for a business unit in the form of higher costs (Fhadillah et al, 2021). Therefore, its existence needs to be eliminated. If it is impossible to eliminate, then its existence must be minimised while still ensuring the smooth fulfilment of user demand. Ideally, there is no need for inventory, but all users' needs can still be met when needed.

Effective inventory control is one of the key components in supply chain management, especially in industries with fluctuating demand and diverse products (Semwal, 2020). PT. XYZ is the main distributor of one of the pharmaceutical companies in West Sumatra, which is the centre for storing products (warehouse) and distributing medicines from the Company to outlets/drug stores, pharmacies, and hospitals in various regions of West Sumatra and outside West Sumatra. The products are also distributed to distributor branches in Bengkulu, Palembang, Pekanbaru, and Jambi.

The important role of PT. XYZ aims to organise and manage production results, including inventory management, but is currently facing challenges in effectively managing its inventory. These challenges include mismatches between order schedules and demand, which often lead to excess or shortage of stock, as well as product damage problems during the distribution process (Foci et al., 2025; Abolhasani & Zavadskas, 2021).

Based on the preliminary survey conducted, the current status is as follows: XYZ has not implemented an effective ordering schedule, leading to significant damage to products and packaging during distribution, which in turn results in stock shortages. The Company receives product demand that fluctuates constantly. However, the Company does not forecast demand for goods, resulting in periods of low demand. Despite this, the Company continues to supply products, leading to an accumulation of excess stock in the warehouse. This can be proven from data on several drugs that experienced stockouts and overstocks during the period July 2023-June 2024.

Table 1. Stock surplus and shortage data of the drug from July 2023 to June 2024

No	Types of Drugs	Package Contents	Packaging Unit	Excess Inventory Amount	Shortage Amount
1	Alkohol 70%	1000 ml	Bottle		499
2	Alkohol 170%	100 ml	Dozen	13391	
3	STT Hijau Merah	50 gr	Bottle		8874
4	Borax Gliserin	16 ml	Dozen	19163	
5	Carbo Gliserin	10 ml	Dozen	14688	
6	Cuka Makan 5%	102 ml	Dozen	7204	
7	Salaf Ichtiol	30 gr	Dozen		144
8	Salaf 2-4	30 gr	Wrap		844
9	Rivanol	100 ml	Dozen	1759	
10	Garam Inggris	30 gr	Dozen	24307	
11	Kaporit	50 gr	Kilogram	4657	
12	Salisil Talk Hijau Merah	46 gr	Dozen	23449	

Table 1 shows that it is increasingly confirmed that PT. XYZ is currently experiencing problems in controlling the inventory of medicinal products in its warehouse, resulting in excess and shortage of medicinal supplies. So far, the product inventory control system in the Company has relied solely on estimates, lacking analytical calculations to determine the optimal ordering amount and time, which has led to uncontrolled product inventory. This will be detrimental to the Company because consumer demand is not met, thus providing opportunities for competitors. In addition, products accumulating in the warehouse are at risk of expiration, which can increase inventory costs and lead to lost sales and profits.

Suboptimal inventory control policies can have a significant impact on a company's operational performance, including increased storage costs, losses due to expired products, and customer dissatisfaction

due to late deliveries (Mardani et al., 2015). Therefore, this research aims to develop an optimised inventory control policy to enhance the efficiency of PT. XYZ's inventory management system. Specifically, it seeks to address key challenges in pharmaceutical inventory control by answering three main research questions: (1) What are the key inventory challenges? XYZ in pharmaceutical distribution (2) How can demand forecasting and inventory classification methods be utilised to improve inventory control, and (3) What is the most effective inventory control model for minimising costs, and optimising inventory turnover at PT. XYZ.

To answer these questions, this study adopts a structured approach, beginning with data collection through historical demand analysis and in-depth interviews with warehouse managers. The ABC classification method and Inventory Turnover Ratio

(TOR) are applied to categorise inventory items based on their significance, while demand forecasting techniques are employed to predict future stock requirements. Furthermore, inventory control models, including the Q model, P model, and the Hadley-Within method, are implemented to develop an optimised inventory policy. The effectiveness of the proposed strategy is then evaluated based on its impact on cost reduction and improvements in inventory turnover. By integrating data-driven forecasting and classification techniques, this research provides a systematic framework for pharmaceutical distribution companies to enhance inventory control efficiency and reduce operational costs.

2.   Research Methods

This study was conducted at PT. XYZ is one of the largest pharmaceutical distribution companies in West Sumatra. The research followed a systematic approach to analyse and optimise the Company's inventory control system. The research began with a preliminary survey, which involved direct observation of PT. A literature review informs XYZ's inventory management processes of relevant studies on inventory control, demand forecasting, and pharmaceutical supply chain management. This phase aimed to identify key challenges, define the scope of the problem, and formulate research questions.

The study utilised secondary data, including historical demand records, product inventory data from July 2023 to June 2024, storage costs, ordering costs, and lead time data. Order costs were assessed based on

annual demand and optimal order quantities, while holding costs were analysed considering optimal order quantity (q), service level, and standard deviation during lead time (Budiningsih & Jauhari, 2017). Additionally, primary data was collected through in-depth interviews with warehouse managers and supervisors. These interviews provided qualitative insights into the challenges faced in inventory control, such as stockouts, overstock, and distribution delays.

To develop an optimised inventory control policy, the study applied the ABC classification method to categorise inventory items based on their importance and contribution to overall stock value. The Inventory Turnover Ratio (TOR) was calculated to evaluate inventory efficiency. A scatter diagram analysis was performed on historical demand data to identify demand patterns, followed by demand forecasting using three different methods. The most accurate forecasting method was selected based on the Mean Absolute Percentage Error (MAPE).

Inventory issues were then classified, with Class A medicines managed using the Q model, while Class B and C were managed using the P model. The Hadley-Within method with backorder was employed to formulate and solve inventory control problems, aiming to minimise costs and improve turnover efficiency. This structured methodological approach ensures a comprehensive evaluation of PT. XYZ's inventory control system provides a data-driven basis for the proposed optimisation strategy. The stages of data processing in this study are shown in Figure 1 below.
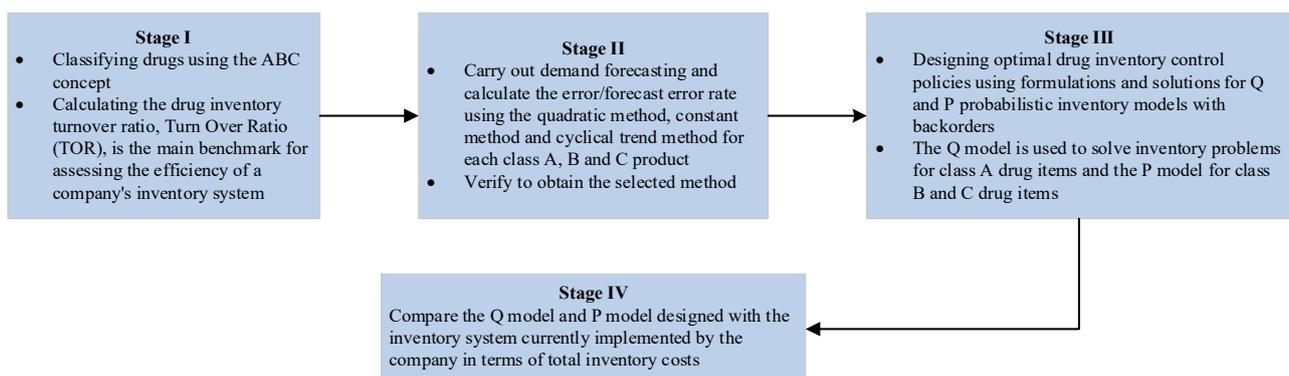

Figure 1. Data Processing Stages

3.   Results and Discussion
3.1. Classification of Drug Items

Classification of drug ítems is done using the ABC analysis method. This method is based on the Pareto principle, where most of the value of an inventory can be attributed to a small portion of the items (Rana, Osman, & Rasul, 2020). By classifying items based on their usage value, companies can allocate greater management resources to the most important items,

thereby improving efficiency and inventory control (Hadi-Vencheh & Mohamadghasemi, 2017).

ABC analysis groups inventory items into three categories: Class A, B, and C. Class A includes items that have the highest usage value and require close supervision, while Classes B and C have lower value and require less supervision (Ahmad, Mehmood, & Khan, 2018). The total number of drugs is 57 drug items where supervision of each drug is carried out with different priorities so that they are classified into three classes, namely class A with strict supervision because

it provides the greatest incentive for the Company with four drug items, class B which is supervised with normal supervision with 14 drug items and class C is carried out with loose supervision with 39 drug items, more details are shown in Table 2. Furthermore, calculate the inventory turnover ratio (TOR) for each drug item using

the formula:

$$TOR = \frac{\text{The sales value over a spesific period (Rp)}}{\text{The ending inventory value for that periode (Rp)}} \quad (1)$$

Table 2. Classification of Drug Items

No	Item Groups	Number of Drug Items	Percentage	Total Sales Value (1 year)	Percentage of Money
1	A	4	7.02%	IDR 15,542,558,525	80.09%
2	B	14	24.56%	IDR 2,890,941,625	14.90%
3	C	39	68.42%	IDR 971,688,543	5.01%
	Total	57	100%	IDR 19,405,188,693	100%

3.2. Demand Forecasting for Medicine

Drug demand forecasting involves plotting historical demand data into a scatter diagram to identify the demand pattern, which is then used to inform a method that follows the pattern. Figure 2 is an example of a demand pattern for STT 50 gr drugs.
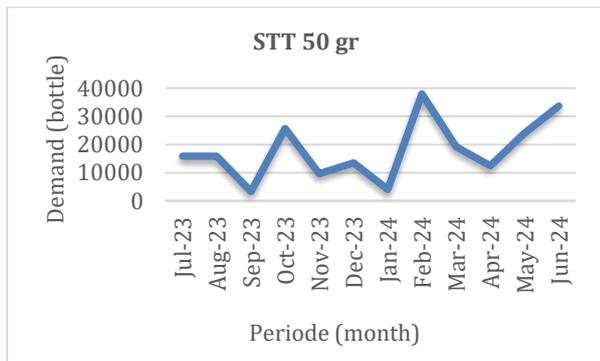

Figure 2. Demand Pattern of STT 50 gr Medicine

Based on the form of the demand pattern, three forecasting methods were chosen, which were closest, namely the quadratic method, exponential smoothing and cyclical trend, so that the demand pattern can be calculated using equations (2), (3) and (4).

$$y' = a + bt + ct^2 \quad (2)$$

$$y' = a \quad (3)$$

$$y' = a + bt + c \sin \frac{2\pi t}{n} + d \cos \frac{2\pi t}{n} \quad (4)$$

The selected method is obtained from the smallest error level using MAPE (Mean Absolute Percentage Error). After verifying the forecast, it turns out that there is no data that goes outside the Upper Control Limit (UCL) and Lower Control Limit (LCL <10%), so the selected method is suitable for further calculations and can be applied by the Company. According to Halimi (2013) in Effendi et al (2019), the MAPE value that has a result of <10% indicates very good forecasting ability.

The drug items classified above are used to determine the proposed inventory control policy. Specifically, drug items in Class A are resolved using

the Q Model, while classes B and C are resolved using the P Model, employing the Hadley-Within method formulation and solution with backorder.

The Q model (Continuous Review System) was chosen for Class A medicines due to their high importance and the necessity for strict inventory control. This model ensures continuous monitoring of stock levels, triggering a replenishment order as soon as inventory reaches the reorder point. Such an approach is particularly effective for high-value, fast-moving pharmaceutical products, where demand fluctuations must be managed efficiently to prevent stockouts and excessive holding costs (Silver, Pyke, & Peterson, 2016). The assumptions of the Q model include a constant demand rate, fixed order quantity, instantaneous replenishment, a known and stable lead time, and minimal shortages if managed properly (Nahmias & Olsen, 2015). These assumptions align with inventory control best practices in pharmaceutical distribution, where continuous monitoring is crucial to maintaining optimal stock levels.

Regarding demand distribution, while the normal distribution assumption is commonly applied in inventory management models, real-world demand patterns often deviate from this ideal condition. To address this, historical demand data was analysed using statistical techniques, including scatter diagrams and demand forecasting models, to determine actual demand behaviour. The study also applied the Mean Absolute Percentage Error (MAPE) to select the most accurate forecasting method, ensuring that the inventory control model remains robust even if demand does not follow a perfect normal distribution (Chopra & Meindl, 2019). If significant deviations from normality were found, alternative forecasting techniques, such as non-parametric methods, were considered to enhance prediction accuracy (Hopp & Spearman, 2011). Therefore, while the normal distribution assumption provides a useful approximation, the model was designed with flexibility to adapt to real demand

variations, ensuring its practical applicability in pharmaceutical inventory management.

3.3. Design of The Proposed Inventory Control Policy

At this stage, the completion of the model used (Q model) is done by finding the total cost that provides the value of the number of orders for one order (Q), the optimal reorder point (r) and the amount of safety stock (SS). The steps proposed by Hadley-Within in determining the values of Q, r, and SS, which are calculated iteratively for one of the drugs, namely STT 50 gr, are as follows.

Step 1. Get all the information about:
Demand (D) = 215,047 bottles (Total demand results 1 year forecasting next, July 2024 – June 2025)
Price (p) = IDR 37,200 / bottle
Fee (A) for 1x order = IDR 374,000
Cost (h) = Proportion holding cost x price of the drug = 0.2 x IDR 37,200 = IDR 7,440
When there is a lack of supplies, then the cost of the lack of inventory (Cu) = 150 % x price of the drug = 150 % x IDR 37,200 = IDR 55,800

Standard deviation (S) = $S = \sqrt{\frac{\Sigma (D_i - \bar{D})^2}{n-1}}$ = 5,216.51

Where, D_i = demand results forecasting
Leadtime = 119 days = 0.326 years

Step 2. Iteration 1 with count mark quantity booking beginning (Q_1)

$$Q_1 = \sqrt{\frac{2AD}{h}} = \sqrt{\frac{2 \times IDR\ 374,000 \times 29,301}{IDR\ 7,440}} = 4,650\ btl$$

Step 3. Based on mark Q_1 is obtained, so we can search for a big possibility of a lack of supply α

$\alpha = \frac{hQ_1}{C_u D}$

$\alpha = \frac{IDR\ 7,440 \times 4,650}{IDR\ 55,800 \times 215,047} = 0,00288$

$Z\alpha = 2.76$.

Step 4. Furthermore, we can calculate r_1 using equality:

$r_1 = DL + z_\alpha S\sqrt{L}$

$r_1 = (215,047 \times 0.326) + 2,76\left(5,216.51\sqrt{0.326}\right)$

$r_1 = 78,334.45\ btl \approx 78,334\ btl$ (rounded)

Step 5. With known mark r_1, then the calculated mark Q_2 using equality:

$$Q_2 = \sqrt{2D\left[A + C_u \int_\eta^\alpha (x - r_1)f(x)dx\right]}$$

Where,

$N = \int_\eta^\alpha (x - r_1)f(x)dx = S_L[f(Z_\alpha) - Z_\alpha\ \Psi(Z_\alpha)]$

Mark $f(Z_\alpha)$ and $\Psi(Z_\alpha)$ can be seen in Appendix J.
$f(2,76) = 0,0088$ and $(\Psi(Z_\alpha) = 1 - \Phi(Z\alpha) = $ 1-0.9971 = 0.0029

So the value of N is:
$N = S_L[f(Z_\alpha) - Z_\alpha\ \Psi(Z_\alpha)]$
$N = 2,978.56\ [\![0,0088\ - 2.76(0.0029)]\!]$
$N = 2,5\ \approx 3$ (rounded)

So mark Q_2 is as follows:

$$Q_2 = \sqrt{2D\left[A + C_u \int_\eta^\alpha (x - r_1)f(x)dx\right]} =$$

$$\sqrt{2D\left[A + C_u \times N\right]}$$

$Q_2 = \sqrt{2 \times 215.047\ [IDR\ 374,000 + IDR\ 7,440(3)]}$

$Q_2 = \sqrt{430,094\ (396,320)}$

$Q_2 = \sqrt{170,454,854,080}$

$Q_2 = 5,450\ btl$

Step 6. Count return mark possibility lack supply α with the equation:

$\alpha = \frac{hQ_2}{C_u D} = \frac{IDR\ 7,440 \times 5,450}{IDR\ 55,800 \times 215,047} = 0.0034$

With $Z\alpha = 2.71$.
Furthermore, we can calculate r_2 by using the equation :

$r_2 = DL + z_\alpha S\sqrt{L}$

$r_2 = (215,047 \times 0.326) + 2,71\left(5,216.51\sqrt{0.326}\right)$

$r_2 = (70,111.21) + 2,27\ (2,978.56)$

$r_2 = (70,111.21) + (6,761.33)$

$r_2 = 78,178.81\ btl \approx 78,179\ btl$

Step 7. Compare marks r_1 and r_2. If the price of r_2 is relatively equal to that of r_1, the iteration is finished, and the result will be r = r_2 and Q_1 = Q_2. If not, go back to step 4 with replace mark r_2 = r_3 and Q_2 = Q_3.
$r_1 = 78,334\ btl$
$r_2 = 78,179\ btl$

Based on the above calculation, it can be seen that the values of r_1 and r_2 are almost the same. Therefore, the iteration is complete, and the following results are obtained :

1. Policy Optimal inventory is:
$Q = Q_2 = 5,450$ btl
$r = r_2 = 78,179$ btl
$SS = z_\alpha S\sqrt{L}$
$SS = 2.71 \times \left(5,216.51\sqrt{0.326}\right)$
$SS = 2.71 \times 2,978.56$
$SS = 8,067.60 \approx 8,068\ btl$ (rounded)

2. Service Level (η)
$\eta = 1 - \frac{N}{D_L} \times 100\ \%$

$\eta = 1 - \frac{3}{215,047\sqrt{0.326}} \times 100\ \%$

$\eta = 1 - \frac{3}{122,789.28} \times 100\ \%$

$\eta = 99.998\ \%$

3. Total cost expectations inventory per year per frequency booking for 1 year is :

$$f = \frac{D}{Q} = \frac{215,047}{5,450} = 39$$

During the period from July 2015 to June 2016, the total frequency of drug orders was 39. Total cost of inventory per year with frequency booking 39 times is:

$$O_T = \frac{AD}{Q} + h\left(\frac{1}{2}Q + D_L\right) + C_u \frac{D}{Q}\int_r^\infty (x-r)f(x)\,dx$$

$$O_T = \frac{IDR\,374,000 \times 215,047}{5,450} +$$

$$IDR\,7,440\left(\frac{1}{2}(5,450) + 18,179.88\right) +$$

$$IDR\,55,800\left(\frac{215,047}{5,450}\right)x3$$

$$O_T = IDR\,40,500,451$$

Total cost annual ($OT_)$ STT 100 gr + 20 % drug covers the cost of order, cost savings and cost of lack of supply, namely:

Total cost message $= \frac{AD}{Q} = \frac{IDR\,374,000 \times 215,047}{5,450} = IDR\,1,758,432$

Total cost saved $= h\left(\frac{1}{2}Q + D_L\right)$
$$= IDR\,7,440\left(\frac{1}{2}(5,450) + 18,179.88\right)$$
$$= Rp\,20,227,920$$

Total cost of $stock = C_u\frac{D}{Q}\int_r^\infty (x-r)f(x)\,dx =$
$C_u\frac{D}{Q}\,N = IDR\,55,800\left(\frac{215,047}{5,450}\right)x3$
$$= IDR\,5,514,107$$

Next, in the first P model, the period time between ordering (T) is determined first, so that a large order lot size (Q) is placed in each period T. Meanwhile, safety stock (SS) is determined simultaneously with the optimisation of annual cost and service level. Completed medication items with the P model. This is the incoming drug item for classes B and C. As for the steps in determining policy optimal inventory with the use of the Hadley-Within method, for example, the calculation of Alcohol 70% 100 ml is as follows.

Step 1. Get all the information about

Demand (D) = 8,268 dozen (Total demand results 1 year forecasting next, July 2024 – June 2025)
Price (p) = IDR 38,400/ dozen
Fee (A) for 1x order = IDR 374,000
Cost (h) = Proportion holding cost x price medicine = 0.2 x IDR 38,400 = IDR 7,680

When possible, there is a lack of supplies, then Cost lack inventory (Cu) = 150 % x price drug = 150 % x IDR 38,400 = IDR 57,600

Standard deviation (S) = $S = \sqrt{\frac{\sum(D_i - \bar{D})^2}{n-1}} = 115.83$

Where, Di = demand results forecasting
Leadtime = 119 days = 0.326 years

Step 2. Calculate T value $_{one}$ beginning with the use equation (iteration 1):

$$T_1 = \sqrt{\frac{2A}{Dh}}$$

$$T_1 = \sqrt{\frac{2 \times IDR\,374,000}{8,268 \times IDR\,7,680}}$$

$$T_1 = \sqrt{\frac{748,000}{63,498,880}} = \sqrt{0.01178} = 0.11\,\text{year}$$

Step 3. Count α and r values with the use of equality:

$$\alpha = \frac{Th}{C_u} = \frac{0.11 \times IDR\,7,680}{IDR\,57,600} = 0.0145$$

By using the NORM.S.INV function in Microsoft Excel or by referring to the standard normal probability density table in Appendix K, the Zα value is found to be 2.18. Then, we can calculate the mark *reorder point* that is

$$r1 = DT + D_L + z_\alpha\sqrt{T+L}$$
$$r1 = (8,268 \times 0.11) + (8,268 \times 0.326) +$$
$$2.18\sqrt{0.11 + 0.326}$$
$$r1 = 3.594\,dozen$$

Step 4. Calculate total costs O_T that is:

$$O_T = Dp + \frac{A}{T} + h\left(R - D_L - \frac{DT}{2}\right) + \frac{C_u}{T}\int_R^\infty (z-R)f(z)\,dz$$

Where is the value $\int_\eta^\alpha (x - r_1)f(x)\,dx = S_L[f(Z_\alpha) - Z_\alpha\Psi(Z_\alpha)] = N$

$$N = S_L[f(Z_\alpha) - Z_\alpha\Psi(Z_\alpha)]$$
$$N = (115.83 \times \sqrt{0.326})[0.0371 - 2.18(0.0145)]$$
$$N = 0{,}6$$

Frequency booking for 1 year is $f = \frac{1}{T} = \frac{1}{0,11} = 9$

So that the total cost value of the supply for 9 times booking can be calculated as follows:

$$O_T = \frac{A}{T} + h\left(R - D_L - \frac{DT}{2}\right) + \frac{C_u}{T}\int_R^\infty (z-R)f(z)\,dz$$

$$O_T = \frac{IDR\,374,000}{0.11} + IDR\,2,832\left(5,620 - 2,695.62 - \frac{8,268\times0.11}{2}\right) + \frac{IDR\,57,600}{0.11}(0,6)$$

$$O_T = IDR\,7,125,381$$

Step 5. Repeat step 2 with changing $T_1 = T_1 + \Delta T_1$

If the result $(O_T)_1$ is a new, bigger value of $(O_T)_1$, beginning with the next iteration, the addition of $_{T1}$ is stopped. Then, try using iteration subtraction ($T_1 = T_1 - \Delta T_1$) until we find a value $T = T1$, which gives the minimum total cost (OT).

Furthermore, done iteration 2. We will try adding T_1 of $\Delta T_1 = 0.05$ years, so $T_2 = 0.16$ years. Furthermore, return to step 3.

$$\alpha = \frac{Th}{C_u} = \frac{0,16 \times IDR\,7,680}{IDR\,57,600} = 0.0211$$

mark Zα = 2.03.
Then, can calculate the mark reorder point that is

$$r2 = DT + D_L + z_\alpha\sqrt{T+L}$$
$$r2 = (8,268 \times 0.16) + (8,268 \times 0.326) +$$
$$2.03\sqrt{0.16 + 0.326}$$
$$r2 = 4,008\,dozen$$

Addition of T_1 becomes T_2 of $\Delta T_1 = 0.05$ years, which will also change the amount of the booking drug, ie $f = \frac{1}{T} = \frac{1}{0,16} = 6$

So that with frequency ordered 6 times for 1 year. Total costs provided are:

$O_T = Dp + \frac{A}{T} + h\left(R - D_L - \frac{DT}{2}\right) + \frac{C_u}{T}\int_R^{\infty}(z - R)f(z)\,dz$

Where is the value $\int_{\eta}^{\alpha}(x - r_1)f(x)dx = S_L[f(Z_{\alpha}) - Z_{\alpha}\,\Psi(Z_{\alpha})] = N$

$N = S_L[f(Z_{\alpha}) - Z_{\alpha}\,\Psi(Z_{\alpha})]$

$N = (115.83\,x\,\sqrt{0.326})[0.0508 - 2.03(0.0211)]$

$N = 0.6$

With so O_T that is:

$O_T = \frac{A}{T} + h\left(R - D_L - \frac{DT}{2}\right) + \frac{C_u}{T}\int_R^{\infty}(z - R)f(z)\,dz$

$O_T = \frac{IDR\ 374,000}{0.16} + IDR\ 7,680\left(6,033 - 2,695.62 - \frac{8,268\ x0.16}{2}\right) + \frac{IDR\ 57,600}{0.16}(0,6)$

$O_T = IDR\ 7,633,989$

Based on the calculation of total costs and annual output after the addition of T above, the resulting costs exceed the total costs before, indicating that the iteration is finished. With this approach, iteration 3 can be done, i.e., reduction T_1 of $\Delta T_1 = 0.05$ years, so $T_3 = 0.06$. Furthermore, return to step 3.

$\alpha = \frac{Th}{C_u} = \frac{0.06\ x\ IDR\ 7,680}{IDR\ 57,600} = 0.0078$

mark $Z\alpha = 2.42$.

Then, we can calculate the reorder point for the mark.

$r3 = DT + D_L + z_{\alpha}\sqrt{T + L}$

$r3 = (8,268\ x\ 0.06) + (8,268\ x\ 0.326) + 2.42\ \sqrt{0.06 + 0.326}$

$r3 = 3,181\ dozen$

Reduction T_1 becomes T_3 of $\Delta T_1 = 0.05$, which will also be the change amount booking drug, ie $f = \frac{1}{T} = \frac{1}{0,06} = 17$

So that with frequency ordered 17 times during 1 year. The total costs provided are:

$O_T = Dp + \frac{A}{T} + h\left(R - D_L - \frac{DT}{2}\right) + \frac{C_u}{T}\int_R^{\infty}(z - R)f(z)\,dz$

Where is the value $\int_{\eta}^{\alpha}(x - r_1)f(x)dx = S_L[f(Z_{\alpha}) - Z_{\alpha}\,\Psi(Z_{\alpha})] = N$

$N = S_L[f(Z_{\alpha}) - Z_{\alpha}\,\Psi(Z_{\alpha})]$

$N = (115,83\,x\,\sqrt{0,326})[0,0213 - 2,42(0,0078)]$

$N = 0,2$

With so O_T that is :

$O_T = \frac{A}{T} + h\left(R - D_L - \frac{DT}{2}\right) + \frac{C_u}{T}\int_R^{\infty}(z - R)f(z)\,dz$

$O_T = \frac{Rp\ 374.000,00}{0,06} + Rp7.680,00\left(5.206 - 2.695,62 - \frac{8.268\ x\ 0,06}{2}\right) + \frac{Rp\ 57.600,00}{0,06}(0,2)$

$O_T = Rp\ 8.432.379,00$

Based on the calculation of the total annual cost generated after the reduction of T above, it shows that the resulting cost is greater than the previous total cost, so the iteration is complete. Furthermore, the steps in calculating the proposed inventory control policy using the Q and P model above are carried out for all types of class A, B, and C drug items. Table 3 presents a summary of the results from calculating inventory costs for the proposed inventory control policy system, compared to the current system used by the Company.

Table 3. Summary of Comparison of Inventory Costs of the Proposed System and the Current System

No	Ordering Cost (IDR/Year)	Storage Cost (IDR/Year)	Cost of Stockout (IDR/Year)	Total Cost (IDR/Year)	Remarks
1	IDR 113,493,842	IDR 210,098,595	IDR 15,629,421	IDR 339,221,858	Proposed System
2	IDR 19,448,000	IDR 1,252,354,255	IDR 66,484,647	IDR 1,338,286,901	Current System
	Cost Savings			**IDR 999,065,044**	
	Percentage of Savings			**74.65%**	

Table 3 shows the current inventory control system at PT. XYZ demonstrates inefficiencies in managing pharmaceutical stock, as evidenced by the high total inventory costs amounting to IDR 1,338,286,901. This is primarily driven by excessive storage costs (IDR 1,252,354,255) and significant stockout costs (IDR 66,484,647). The high storage costs indicate an overstocking issue, leading to increased holding expenses, while the substantial stockout costs suggest frequent shortages, which could disrupt pharmaceutical supply and impact patient care. Additionally, the order fee under the current system is significantly lower (IDR 19,448,000), implying that large batch orders are placed irregularly, contributing to inefficient stock replenishment cycles.

In contrast, the proposed inventory control system significantly improves cost efficiency, reducing total inventory costs to IDR 339,221,858, achieving a cost saving of 74.65% (IDR 999,065,044). This is attributed to a more balanced approach in order placement, as reflected in the higher order fee (IDR 113,493,842). The increase in ordering frequency ensures optimal stock levels, thereby reducing storage costs (IDR 210,098,595) and stockout costs (IDR 15,629,421).

To further validate the robustness of the proposed model, a sensitivity analysis was conducted by adjusting key variables, such as demand fluctuations, lead time variability, and cost parameters. The results indicate that the proposed Q and P models remain stable under moderate demand fluctuations, demonstrating adaptability in real-world scenarios. However,

significant increases in demand volatility (above 30%) could lead to increased stockout risks, necessitating additional safety stock adjustments. Similarly, lead time variability beyond the assumed limits negatively impacts reorder point accuracy, highlighting the importance of real-time monitoring and dynamic adjustments in the inventory control strategy. Overall, the findings suggest that while the proposed model provides a substantial improvement over the current system, future research could explore dynamic inventory control models incorporating real-time demand forecasting and adaptive replenishment strategies to further enhance efficiency.

4. Conclusion

The findings of this study indicate that the proposed inventory control policy can be effectively implemented at PT. XYZ, particularly for Class A drug items. These items are managed using a probabilistic Q model, incorporating the Hadley-Within method with backorders. For instance, the optimal policy for STT 100 gr + 20% involves an order lot (Q) of 5,450 bottles, a reorder point (r) of 78,179, and a safety stock (SS) of 8,068 bottles. Meanwhile, Class B and C drug items are addressed using a probabilistic P model, also utilising the Hadley-Within method with backorders. For example, the optimal policy for 70% Alcohol 100 ml requires an order period (T) of 0.11 years, a reorder point (r) of 3,594 dozens, and a safety stock (SS) of 144 dozens. The proposed policy results in a total inventory cost of Rp339,221,858, significantly lower than the current system's cost of IDR 1,338,286,901, yielding a cost reduction of 74.65% (IDR 999,065,044).

Despite these promising results, this study has several limitations. Firstly, the demand forecasting model assumes relatively stable demand, which may not fully capture fluctuations due to unforeseen factors such as regulatory changes or supplier disruptions. Secondly, this study focuses on a single pharmaceutical distributor, limiting the generalisability of the findings to other companies with different operational structures. Additionally, the research does not account for real-time dynamic adjustments in inventory policies, which could further enhance efficiency. For future research, it is recommended to explore hybrid inventory control models that integrate real-time data analytics and machine learning to improve forecasting accuracy. Additionally, conducting a comparative study across multiple pharmaceutical distributors could provide deeper insights into the adaptability of the proposed model in different supply chain environments.

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