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PROCEEDING

9th ISIEM

The 9th International Seminar on Industrial Engineering and Management

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Organized by :

Industrial Engineering Department of

•Trisakti University• Al Azhar Indonesia University•
• Esa Unggul University•Telkom University•
•Tarumanagara University •Pasundan University •
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PREFACE

Dear Presenters and Delegates,

On behalf of the Organizing Committee, I am honored to welcome you to the 9th International Seminar on Industrial Engineering and Management (ISIEM). This seminar is organized by the Industrial Engineering Department from eight Universities, namely Trisakti University, Telkom University, Tarumanagara University, Atma Jaya Catholic University of Indonesia, Al Azhar Indonesia University, Esa Unggul University, Pasundan University, and Bung Hatta University.

The theme **"Collaborative Innovation Towards Borderless Industrial and Economic System"** which in accordance with the current economic era, we hope that through the exchange of ideas, experiences and recent progress in Industrial Engineering and Management from academicians, engineers, professionals and practitioners from Universities, research institutions, government agencies and industries be able to help us to deal with future challenges.

We hope that our presenter and delegates will gain many shared ideas and great experiences from this conference and also acquire additional insights from our honorable speakers, **Gursel Ilipinar, PhD** from ESADE Business School – Barcelona, **Profesor Emeritus Dato' Ir. Dr. Zainai Bin Mohamed** from UTM Razak School of Engineering and Advance Technology – Malaysia, **Milko-Pierre Papazoff** from Vice President of French External Trade Counsellor (Malaysian Chapter).

The success of this seminar is due to the hard efforts of many people who we gratefully acknowledge. Special thank to all reviewers, speakers, and presenters, also highly appreciate to the committee for mutual effort and invaluable contribution.

Finally, we hope you will enjoy this conference and the natural beauty of Padang city – Indonesia and see you in the next ISIEM.

Best wishes,

Chair of the 9th ISIEM 2016

Dr. Wisnu Sakti Dewobroto, M.Sc

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DRUG INVENTORY POLICY PROPOSAL USING PROBABILISTIC METHODS TO INCREASE THE SERVICE LEVEL

Sabila Syafitri Pambudi[1], Dida Diah Damayanti[2], Budi Santosa Chulasoh[3]

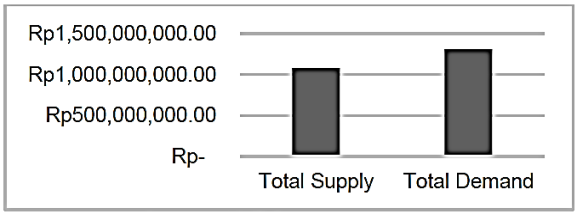
Department of Industrial Engineering, Telkom University, Bandung, Indonesia
[1]sabilasyafitri@gmail.com, [2]didadiah@telkomuniversity.ac.id, [3]budisantosa@telkomuniversity.ac.id

ABSTRACT

XYZ Bandung Hospital has a pharmaceutical depot that provides pharmaceutical goods such as medicine. The depot has 216 drugs SKU that still active. XYZ Bandung Hospital has not inventory policy based on standardizing calculation yet. It caused stockout that resulted in losing sales and decreasing in service level. This research aims to give advice about the drug inventory policy to improve the service level. The demand data is probabilistic so that to determine the policy proposals use probabilistic methods continuous review (s, S) system for first inventory policy proposal and periodic review (R, s, S) system for second inventory policy proposal. For determining the drugs priority is used both ABC analysis and VED analysis that resulted in two priority group of drugs. But this research only focuses on first priority category.The results of this research are inventory control variables which are the optimal order quantity, reorder point and safety stock. Based on the calculation, using the first inventory policy proposal can reduce the total inventory up to Rp54.227.661,27 and increase the service level up to 7.93% and using the second inventory policy proposal can reduce the total inventory cost up to Rp41.145.751,49 and increase the service level up to 1.90%.
Key words: Inventory Policy, Stockout, Continuous Review (s,S) System, Periodic Review (R,s,S) System.

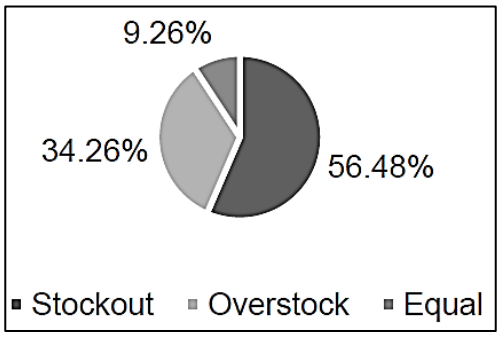
1. INTRODUCTION

Pharmaceutical depot of XYZ Bandung Hospital has 216 stock keeping unit (SKU) for drugs that are still active. In the pharmaceutical depot is found in conditions where there are inventory and demand differs. The total inventory is smaller than the total demand that shown in Figure 1.



Source : XYZ Bandung Hospital
Figure 1. Comparison of Total Supply and Total Demand

Figure 1 shows that the total demand is higher than the total inventory. It indicates exist demand that can not be fulfilled which will decrease the service level to consumers. The inability to fulfill consumer's demand caused by there is not available inventory of the desired item on the pharmaceutical depot XYZ Hospital Bandung.



Source : XYZ Bandung Hospital
Figure 2. Percentage of Total Stock out, Overstock, and Equal Item

Figure 2 shows that the difference that arises between the total inventory and total demand is dominated by under stock out condition items that are about 56.48%. This stock out condition caused lost sales resulting from hospital inability to fulfill the demand that occurred. Stock out condition also caused lost sales costs that to be borne by the hospital. Figure 2 also shows that

there is overstock condition caused stack inventory asset costs that also to be borne by the hospital. It caused by inventories which not sold.

Source : XYZ Bandung Hospital

Figure 3. Comparison between Total Lost Sales Cost and Total Stack Inventory Asset Cost

Figure 3 shows the costs that borne by the hospital. The high cost of lost sales will affect the high of total inventory cost that borne by the hospital. Therefore, it will be proposed the inventory control planning for first priority of drug in the pharmaceutical depot of XYZ Bandung Hospital using probabilistic methods continuous review (s, S) and periodic review (R, S, S) system.

2. THEORETICAL BACKGROUND

Probabilistic inventory control method is a method of inventory control where the phenomenon is not known, but the expectation value, variance and pattern distribusi likely predictable (Bahagia, 2006).

2.1. Continuous Review (s, S) System

In continuous review (s, S) system, every order quantity is fixed. Order will be done if the inventory level has reached at reorder point (s) and the inventory will be filled until the point of maximum inventory (S). S value obtained from the addition reorder point and order quantity (Silver, Pyke, & Peterson, 1998).

Total Inventory Cost and Service Level Formulation (Bahagia, 2006).

1. Order Cost
$$Op = \frac{A.D}{q_0} \quad (1)$$
2. Holding Cost (for lost sales case)
$$Os = h\left(\frac{q_0}{2} + s - DL + N\right) \quad (2)$$
3. Shortage Cost
$$Ok = \frac{C_u.D}{q_0} N \quad (3)$$
4. Total Inventory Cost
$$OT = Op + Os + Ok \quad (4)$$
5. Service Level
$$\eta = \frac{N}{q_0^*} x100\% \quad (5)$$

Hadley Within Model Formulation for Continuous Review System Inventory Policy (Bahagia, 2006).

1. Calculate value of q_{01}^* with Wilson formula
$$\mathrm{q}_{01}^* = \mathrm{q}_{0\mathrm{w}}^* = \sqrt{\frac{2.\mathrm{A.D}}{\mathrm{h}}} \quad (6)$$
2. Find the value of shortage inventory probability
$$\alpha = \frac{h.\mathrm{q}_{01}^*}{h.\mathrm{q}_{01}^* + C_u D} \quad (7)$$
3. Find the value of reorder point
$$s_1^* = D.L + Z_\alpha.\sigma\sqrt{L} \quad (8)$$
4. Find N (expected shortage inventory) to find q_{02}^*
$$N = \sigma_L[f(Z_\alpha) - (Z_\alpha)\Psi(Z_\alpha)] \quad (9)$$
$$q_{02}^* = \sqrt{\frac{2.D\left[A + C_u \int_{s_1^*}^{\infty}(x - s_1^*) f(x)dx\right]}{h}} \quad (10)$$
5. Recalculate the value of α to find
$$\alpha = \frac{h.\mathrm{q}_{02}^*}{h.\mathrm{q}_{02}^* + C_u D} \quad (11)$$
$$s_2^* = D.L + Z_\alpha.\sigma\sqrt{L} \quad (12)$$
6. Compare the value of s_1^* and s_2^*. If $s_1^* = s_2^*$, iteration finish and the result is $s^* = s_2^*$ and $q_0^* = q_{02}^*$. But, if $s_1^* \neq s_2^*$*, back to the third step with replace the value $s_1^* = s_2^*$ and $q_1^* = q_2^*$
7. Calculate the value of safety stock
$$ss = Z_\alpha.\sigma\sqrt{L} \quad (13)$$
8. Calculate the value of maximum inventory level (S)
$$S = q_0^* + s^* \quad (14)$$

where,

q_{01}^* = order quantity (unit)
A = order cost (Rp/order)
D = demand (unit)
h = holding cost (Rp/unit/period)
α = shortage inventory probability (unit)
Cu = shortage cost per unit (Rp/unit)
s_i^* = reorder point (unit)
L = lead time (day or year)
Z_α = normal deviation
σ = standard deviation
f(Z_α)= ordinate

$\Psi(Z_\alpha)$= partial expectation
N = shortage inventory (unit)
η = service level (%)

2.2. Continuous Review (s, S) System

In periodic review (R, s, S) system, every order is not fixed. At any time R unit, an review of the inventory will be done. If the stock is at or below reorder point (s), then the order is made until it reaches the point of maximum inventory (S). But if the stock is above s, the order will not be done until next inventory review (Silver, Pyke, & Peterson, 1998).

Total Inventory Cost Formulation
(Bahagia, 2006).

1. Order Cost
$$Op = \frac{A}{R} \quad (15)$$
2. Holding Cost (for lost sales case)
$$Os = h\left(R - D_L + \frac{D.R}{2}\right) \quad (16)$$
3. Shortage Cost
$$Ok = \left(\frac{C_u}{R} + h\right) xN \quad (17)$$
4. Total Inventory Cost
$$OT = Op + Os + Ok \quad (18)$$
5. Service Level
$$\eta = (1 - \alpha) \times 100\% \quad (19)$$

Hadley Within Model Formulation for find The Value of Order Interval on Periodic Review System Inventory Policy (Bahagia, 2006).

1. Calculate value of R_0
$$R_0 = \sqrt{\frac{2.A}{D.h}} \quad (20)$$
2. Find the value of shortage inventory probability
$$\alpha = \frac{R_0.h}{R_0^1.h + C_u} \quad (21)$$
3. Find the value of reorder point
$$S^* = D(R_0 + L) + Z_\alpha\sqrt{R_0 + L} \quad (22)$$
4. Find N (expected shortage inventory) to find q^*_{02}
$$N = \sigma\sqrt{(R_0 + L)}[f(Z_\alpha) - (Z_\alpha)\Psi(Z_\alpha)]q^*_{02} \quad (23)$$
5. Find the expected value of total inventory cost
6. After calculate the total inventory cost for first priority group, the next step is determine the value of order interval (R) by recalculate with the same calculation but with different value of R_0 . So, to determine the optimum of R can be decided by campare its total inventory cost that is produced by each value of R.

Silver Model Formulation for Periodic Review System Inventory Policy (Silver, Pyke, & Peterson, 1998).

1. Determine the value of order interval (R)
2. Calculate the value of X_R and X_{R+L}
$$X_R = D.R \quad (24)$$
and,
$$X_{R+L} = D(R + L) \quad (25)$$
3. Calculate the value of (r) and σ_{R+L}
$$r = hxR \quad (26)$$
and,
$$\sigma_{R+L} = \sigma(R + L) \quad (27)$$
4. Find Qp value
$$Q_p = \left(1{,}30xX_R^{0{,}494}\right)x\left(\frac{A}{p.r}\right)^{0{,}506} x\left(1 + \frac{\sigma^2_{R+L}}{X^2_R}\right)^{0{,}116} \quad (28)$$
5. Calculate the value of z and s
$$z = \sqrt{\frac{Q_p.r}{\sigma_{R+L}.C_u}} \quad (29)$$
and,
$$s = (0{,}937xX_{R+L}) + \sigma_{R+L}\left(\frac{0{,}183}{z} + 1{,}063 - 2{,}192z\right) \quad (30)$$
6. Find S value
$$S = Q_p + s \quad (31)$$
7. Find safety stock value
$$ss = Z_\alpha\sqrt{L} \quad (32)$$
8. Calculate the value of total inventory cost and service level.

where,
X_R = expected demand along order interval (unit)
X_{R+L} = expected demand along order interval and lead time (unit)
D = demand (unit)
R = interval review (day or year)
r = holding cost per unit per order interval (Rp)
σ_{R+L} = standard deviation of demand along order interval and lead time (unit)
h = holding cost per unit per periode (Rp/unit)
Qp = expected optimal order quantity (unit)
p = price per unit (Rp/unit)
s = reorder point (unit)
S = maximum inventory level (unit)
ss = safety stock (unit)

Z_α = normal deviation
σ = standard deviation
L = lead time (dar or year)
N = shortage inventory (unit)
A = order cost (Rp/order)
α = shortage inventory probability (unit)
Cu = shortage cost per unit (Rp/unit)
η = service level (%)

3. RESEARCH METHOD

The conceptual model is the framework of formula solution plan that explains the relevance of variables in this research to produce an output by the research purpose.

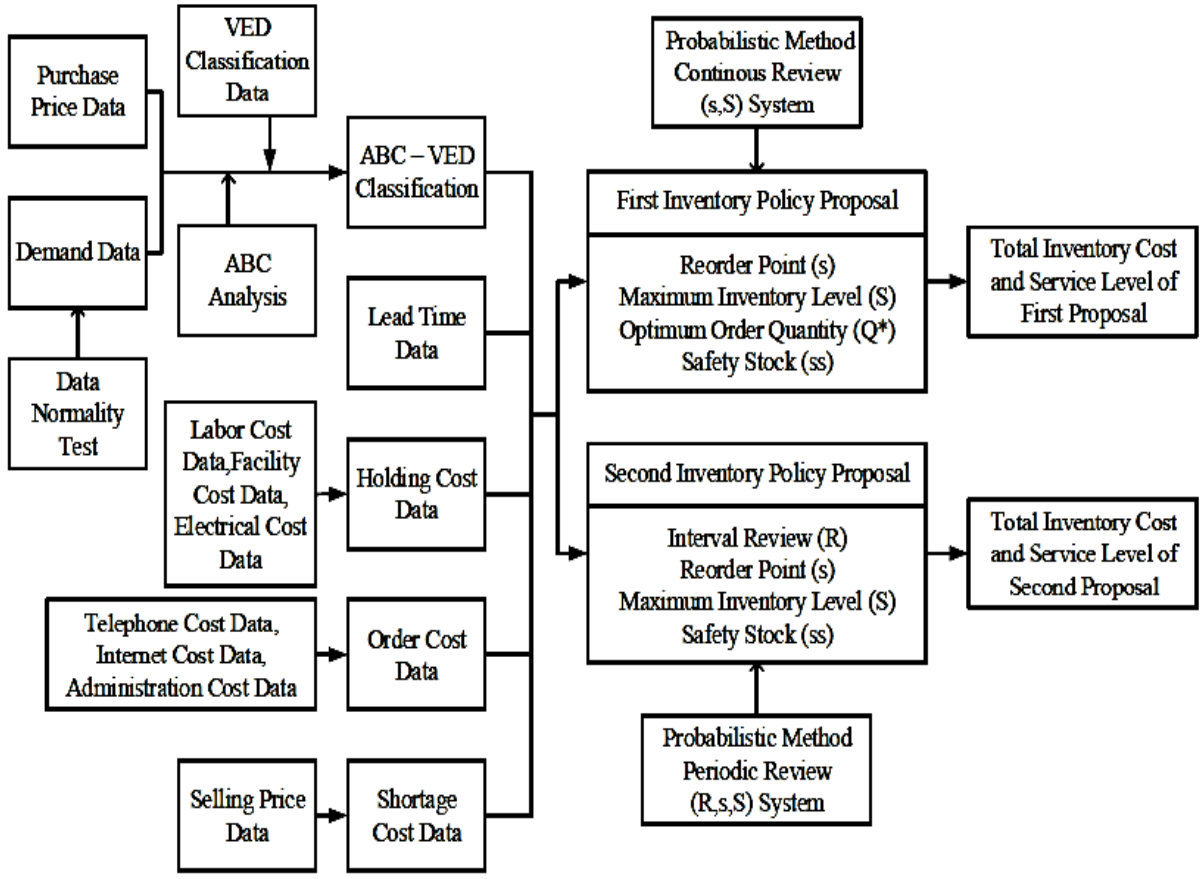


Figure 4. Conceptual Model

4. RESULT AND DISCUSSION

4.1. ABC-VED Classification

Merging ABC-VED classification produce 9 combinations, namely AV with 14 SKUs, AE with 19 SKUs, AD with 28 SKUs, BV with 7 SKUs, and CV with 21 SKUs which became first priority group of drug and BE with 19 SKUs, BD with 37 SKUs, CE with 22 SKUs, and CD with 49 SKUs which became second priority group of drug. So the number of SKU in the first priority group of drug that will be the object of this research is as much as 89 SKUs.

4.2. Existing Total Inventory Cost and Service Level

ACTRAPID HM 100UI

Total Inventory Cost
OT = Holding cost + Order cost + Shortage cost
= (h x m) + (f x A) + (N x Cu)
= (0 x Rp 306.93) + (0 x Rp 6,735.30) + (600 X Rp 58,483.33)
= Rp 0,00 + Rp 0,00 + Rp 35.090.000,00
= Rp 35.090.000,00

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Service Level

$$\eta = \frac{Demand\ that\ can\ be\ fulfilled\ immediately}{Demand\ that\ come\ on\ the\ period} x100\%$$

$$\eta = \frac{0}{600} x100\% = 0\%$$

4.3. Total Inventory Cost and Service Level Result Calculation for Proposed Condition

ACTRAPID HM 100IU

Total Demand (D) = 600 unit
Standard Deviasi (σ) = 63,96
Holding Cost (h)/unit = Rp 306,93
Ordr Cost (A)/order = Rp 6.735,30
Shortage Cost (Cu)/unit = Rp 58.483,33
Lead time (L) = 0,0082 year

4.3.1. First Proposed Inventory Policy Calculation Result using Probabilistic Method Continuous Review (s, S) System

Table 1. Inventory Policy for ACTRAPID HM 100IU using Continuous Review

Policy	Value
Optimum order quantity	505 unit
Reorder point	21 unit
Maximum order quantity	526 unit
Safety stock	16 unit

Based on Tabel 1, service level for ACTRAPID HM 100IU is about 99,80% and service level for first priority of drug on first proposed inventory policy is about 99,11%.

Table 2. Total Inventory Cost Exoectation for ACTRAPID HM 100IU using Continuous Review

Cost Component	Cost
Order Cost	Rp 13.470,60
Holding Cost	Rp 82.432,93
Shortage Cost	Rp 165.388,68
Total Inventory Cost	Rp 165.388,68

Total inventory cost for first priority of drug on first proposed inventory cost is about Rp7.159.960,34.

4.3.2. Second Proposed Inventory Policy Calculation Result using Probabilistic Method Periodic Review (R, s, S) System

Table 3. Inventory Policy for ACTRAPID HM 100IU using Periodic Review

Policy	Value
Interval order	99 days
Reorder point	886 unit
Maximum order quantity	887 unit
Safety stock	18 unit

Based on Tabel 3, service level for ACTRAPID HM 100IU is about 99,86% and service level for first priority of drug on first proposed inventory policy is about 93,07%.

Table 4. Total Inventory Cost Exoectation for ACTRAPID HM 100IU using Periodic Review

Cost Component	Total
Order Cost	Rp26.941,20
Holding Cost	Rp295.640,82
Shortage Cost	Rp216.547,47
Total Inventory Cost	Rp539.129,49

Total inventory cost for second priority of drug on second proposed inventory cost is about Rp17.513.501,45

4.4. Calculation Result Comparison of Existing and Proposed Condition

Table 5. Order Cost Comparison

Condition	Order Cost	Difference
Existing	Rp 4.209.562,50	
Continuous Review (s,S)	Rp 2.606.561,10	Reduce Rp 1.603.001,40
Periodic Review (R,s,S)	Rp 2.943.326,10	Reduce Rp 1.266.236,40

Order cost reduce on proposed condition occurs since there is a reorder point policy on proposed condition for each SKU, so the ordering frequency is fewer than existing condition.

Table 6. Holding Cost Comparison

Condition	Holding Cost	Difference
Existing	Rp 1.123.994,04	
Continuous Review (s,S)	Rp 3.613.616,92	Increase Rp 2.489.622,88
Periodic Review (R,s,S)	Rp 12.009.114,60	Increase Rp 10.885.120,56

Holding cost rising on proposed condition occurs since there is the rising level of inventory at the proposed conditions. It causes a rise in the holding cost that also indicates a reduction risk of inventory shortages that lead to lost sales.

Table 7. Shortage Cost Comparison

Condition	Order Cost	Difference
Existing	Rp 55.614.741,83	
Continuous Review (s,S)	Rp 939.782,32	Reduce Rp 54.674.959,51
Periodic Review (R,s,S)	Rp 2.561.060,75	Reduce Rp 53.053.681,08

Shortage cost reduces on proposed condition related to the increase in holding cost. This reduction also indicates a reduction risk of shortages inventory were followed by increase in inventories.

Table 8. Total Inventory Cost Comparison

Condition	Order Cost	Difference
Existing	Rp 60.948.298,37	
Continuous Review (s,S)	Rp 7.159.960,34	Reduce Rp 53.788.338,03
Periodic Review (R,s,S)	Rp 17.513.501,45	Reduce Rp 43.434.796,92

Total inventory cost reduces on proposed condition showed the improvement made from existing conditions. It occurs since there is inventory policy based on standardizing calculation on proposed conditions.

Table 9. Service Level Comparison

Condition	Holding Cost	Difference
Existing	90,59%	
Continuous Review (s,S)	99,11%	Increase 8,52%
Periodic Review (R,s,S)	93,07%	Increase 2,48%

Service level rising on proposed conditions caused by rising levels of inventories on the proposed conditions. So that demand was coming can be fulfilled by the hospital.

5. CONCLUSION

1. In this research produced two inventory policy proposals. First inventory policy proposal is using probabilistic method continuous review (s, S) system, while second inventory policy proposal is using probabilistic methods periodic review (R, s, S) system. By using continuous review (s, S) system on the first proposal, then the drug ACTRAPID HM 100IU have reorder point when inventory level is at the level of 21 units, the number of optimum order quantity are about 505 units, its safety stock as much as 16 units and its maximum inventory level are 526 units. While using periodic review (R, s, S) system on the second proposal, then the drug ACTRAPID HM 100IU has inventory review interval per 99 days, safety stock as much as 18 units, reorder point when inventory level are at the level of 886 units and its maximum inventory level are 887 units.
2. The first proposed total inventory cost produced was at Rp7.159.960,34. While the second proposed total inventory cost produced was Rp17.513.501,45. The total inventory cost resulting from both these proposals has a smaller value of the total cost of inventory on existing condition that has a total inventory cost by Rp60.948.298,37. The first proposed condition reduces the total inventory up to 88,25% less than the existing total inventory cost while the second proposed condition reduces the total inventory up to 71,26% less than the existing total inventory cost.

3. The service level that is produced on the first proposed condition amounted to 99.11% while the service level on the second proposed condition amounted to 93.07%. The service level resulting from both these proposals have a higher value than the service level on the existing condition that has a service level amounted to 90.59%. Increased service level in both conditions, this proposal shows the increasing availability of drugs on the pharmaceutical depot of XYZ Bandung Hospital, so stockout problems that occur can be improved.

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