INVENTORY PLANNING FOR FAST MOVING CONSUMER GOODS USING PERIODIC-REVIEW ORDER-UP-TO-LEVEL (R, S) SYSTEM IN RETAIL X BANDUNG

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ABSTRACT

Retail X is forced to face the decline in sales in the holiday season and increase when course season. However, the use of past data to predict sales have not considered the seasons, so it can be predicted that there are errors on the results of the sales forecast. This lead the researchers to use two proposed conditions, the first is the proposed condition 1 that will use the past data which regard the season and the second is the proposed condition 2 that will not pay any attention to the season. In proposed condition calculation will use Periodic-Review, Order-Up-to-level (R, S) system. The results of the application of the inventory policy on the proposed conditions 1 can save the inventory total cost by 8% or Rp 40,948 at each inventory review interval and lead time.

Keywords*: Inventory; retail; R,S system*

1. INTRODUCTION

One of the key areas that play an important role in the operation of a retail is an inventory control system. This study will raise the issue at Retail X that do not apply to the appropriate inventory policies. Retail X determines the amount of order quantity (OQ) to distribution center management based solely on intuition and without any mathematical calculations. The absence of appropriate inventory policies have made the Retail X faces problems such as out-of-stock or over-stock.

In this study, there should be a comparison of the proposed and actual inventory policies to determine the most efficient policy will be implement in next period. The period used to compare the calculation of proposed and actual inventory policy is first review interval (R) in December. In determining policy, one thing to note is that prior period sales data. Retail X which has a primary target market students are forced to face the decline in sales during the holiday courses and increasing sales back in the lecture. The sales decline can be seen in chart patterns X Retail sales for the year 2012 as follows:

Figure 1. Retail X Sales 2012 (source: Retail X)

Figure 1 shows that in June, July and August (Quadrant I) which is the holiday period, sales declined and the rest in the lecture (quadrant II) sales increased and more stable. Changes in the pattern of sales between Quadrant I and Quadrant II can significantly affect the inventory policies to be implemented because of past sales patterns are used to predict the future sales. Therefore, the researchers will distinguish past sales data usage to 2 conditions. The first condition (Proposed Condition 1) is the use of sales data for the last 4 months that are in the same quadrant of the period to be counted. Period to be counted, in December, was at the lecture (quadrant II), so the sales data used in the proposed condition 1 is the data in September,

October, November and May are also located in quadrant II. While the second condition (Proposed Condition 2) will use sales data for the last 4 months without regard to the existence of the quadrants in the period to be examined, so that the sales data used is in August, September, October and November. After obtaining the inventory policies of the two proposed conditions, then will be compared to the total inventory cost between the two inventory policies in proposed conditions and actual condition.

2. THEORETICAL BACKGROUND

Periodic-Review, Order Up To Level (R,S) System

In this system, re-ordering is done periodically, where the review interval (R) is fixed, but varies order quantity according to the inventory on hand in the last of review interval (R) (Silver, Pvke, Peterson, 1998).

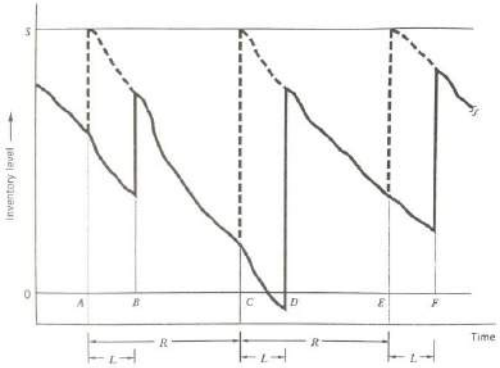

Figure 2. *Periodic-Review, Order-Up-To-Level (R,S) System*

According to Silver, E., Pvke, D., & Peterson, R., (1998), there are 2 main parameters used in the calculation of the R, S system, namely:

1. Review Interval (R)

Interval can be a constant time interval such as every week, every month or every year. Rated R has been determined in advance to obtain the optimal value of S.

2. Maximum Inventory Level (S)

Maximum inventory level (S) is the optimal maximum inventory. In the inventory control system (R, S), the maximum value of inventory should be able to meet demand during the review interval and lead time (R + L). In this study, it takes several parameters to perform calculations using the R, S system, namely:

R	=	Inventory review interval, in
S	=	Maximum inventory level, in
L	=	*lead time*, in month
$\bar{x}$	=	average product sales, in unit
$\bar{x}_{R+L}$	=	expected product sales during R and L, in unit
σ	=	standart deviation, in unit
σ_{R+L}	=	standart deviation product sales during R and L, in unit
K	=	safety factor
SS	=	safety stock
IOH	=	inventory on hand, in unit
OQ	=	order quantity, in unit
ESPRC	=	Expected Shortage Per Replenishment Cycle
Gu(k)	=	partial expectation
Os	=	holding cost during R and L, in Rupiah
Op	=	Procurement cost, in Rupiah
Ok	=	Shortage cost, in Rupiah
OT	=	total inventory cost, in Rupiah

Calculation of Safety Stock (SS)

Calculation of safety stock for the periodic review system is as follows:

Safety stock (SS) = k x σ_{R+L} (1)

$\sigma_{R+L} = \sigma \times \sqrt{R+L}$ (2)

$\sigma = \sqrt{\frac{\sum(Xi-\overline{X})^2}{n-1}}$ (3)

Calculation of Maximum Inventory Level (S)

Maximum inventory level (S) = expected product sales during R and L ($\bar{x}_{R+L}$) + Safety stock (SS)

where,

$\bar{x}_{R+L}$= (R+L) x $\bar{x}$ (4)

So that, the pattern for the maximum inventory level (S) is:

the maximum inventory level (S) = { (R+L) x $\bar{x}$ } + {k x (σ x $\sqrt{R+L}$ } (5)

Inventory on Hand (IOH)

Inventory on hand is an inventory stock of the company at a certain period. In a periodic review inventory models, inventory on hand is the existing inventory at the end of the period and can be used in the future periods.

Calculation of Order Quantity (OQ)

Order Quantity (OQ) is the size of the products that will be ordered at the end of the review interval (R) or the reorder point.

Order quantity = Maximum inventory level (S) - Inventory on hand (IOH)

Order quantity = {(R+L) x $\bar{x}$ } + {k x (σ x $\sqrt{R+L}$ } – IOH (6)

Calculation of Total Inventory Cost (OT)

Total inventoy cost (OT) is the accumulation of the three components of cost, those are shortage cost (Ok), holding cost (Os) and procurement cost (Op).

OT = Os + Op + Ok (7)

In calculating Ok, it is calculated when there is a shortage and the expected shortage per replenishment cycle (ESPRC).

ESPRC = σ_{R+L} x Gu(k) (8)

Service Level

Service level is a service value set by the company, which is included in the calculation of inventory in order to meet the needs of customers (Ballou, 2004). There are several ways to explain the service level, namely:

a. Service level is a possibility when a customer requests can be met from inventory during lead time in a cyclical order.
b. Service level is the percentage of requests that can be fulfilled from stock within a certain time period (Then Sumayang 2003:210).

According to Chase and Aquilano, it is usual for companies to use approaches 95% for no having the possibility of out-of-stock.

3. RESEARCH METHOD

Framework of problem solving

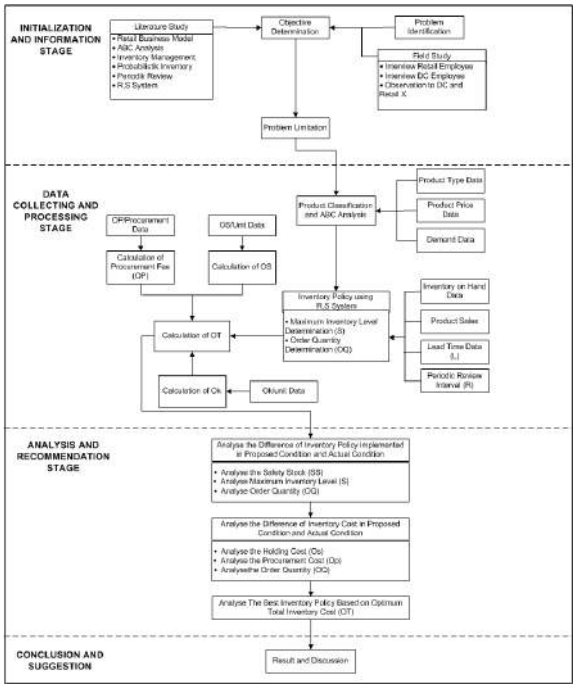

Figure 4. Framework of problem solving

Initialization and information stage

1. Problem Identification

Problem identification is the activity of collecting, documenting and formulating the problems faced by Retail X. Thus, the general formulation of Retail X problems are how to calculate the amount of safety stock (SS), how to calculate the maximum level of inventory (S) and how to determine the order quantity (OQ) to reach the minimum inventory total cost.

2. Research Objective

This study aimed to determine the inventory policy that covers the maximum inventory level (S) and the order quantity (OQ) for optimum product category A in Retail X. The ultimate goal of this research is that there is an optimum total cost of inventory so as to increase profits Retail X.

3. Literature Study

The study of literature is the activity of studying the concepts from literature related to the research. The literature studied includes theory:

- Retail Business Model
- ABC Analysis
- Inventory Management
- Inventory for probabilistic demand
- Periodic Inventory Review
- R,S System

4. Field Study

The field study was conducted through direct observation into the field to a distribution center (DC) and Retail X.

Data Collecting and Processing Stage

In this stage, data collecting and processing, types of data used consists of primary data and secondary data. The data required is the collection of data types and prices of products, demand data, sales data, inventory data and cost data lead time. Data types and prices of products and demand data will be used to classify products by category A, B or C. A product category with the largest value of the absorption of funds is a product that will be investigated further. In addition, the data to be processed is sales data, review interval (R) and the lead time (L) to obtain an optimum inventory policy.

Determining inventory cost (OT) may be made after the determination of inventory policies have done. OT needs some cost components, namely holding cost (Os), procurement cost (Op) and shortage cost (Ok). The holding cost (Os) requires holding cost / unit data, the procurement cost requires the cost data set for the Retail X to DC on every order and shortage costs (Ok) requires the cost of lack product / unit in case of out-of-stock.

Analysis and Recommendation Phase

At this stage, the analysis and interpretation of the results of the research is conducted. This section consists of the analysis and interpretation of the data that has been processed to obtain the minimum Total Inventory Cost (OT). Analysis of the calculation for inventory policies on the proposed conditions and actual conditions include maximum inventory level (S) and analysis of order quantity (OQ).

After analyzing inventory policies, the total inventory cost (OT) needs to be re-analyzed to determine the most appropriate inventory policies. The inventory policy that has a minimum OT may indicate that it will be appropriate to be implemented by the Retail X. In the end, inventory policies will be recommended to Retail X.

4. RESULTS AND DISCUSSION

Data Collection

In support of this research, it takes some baseline data that must be collected and managed as follows:

1. Product Type
2. Retail X to DC Demand
3. Product Price Data
4. Retail X Sales Data
5. Review Interval (R)
6. *Lead time* (L)
7. Holding Cost (Os)
8. Procurement Cost (Op)
9. Shortage Cost (Ok)

Product Type

There are 1667 types of products Fast Moving Consumer Goods (FMCG) owned by Retail X. Each product type has differences in terms of absorption of funds that needs to be classified using ABC analysis. In the end, only the product category A to be managed further in this study.

Retail X to DC Demand

Retail X to DC demand is a number of products requested by Retail X to DC to meet customer needs. The data used is for 12 months from January 2012 - December 2012.

Product Price

Product price is a cost of the product that Retail X bought. Product price and the demand from Retaill X to DC are required to determine the fund absorption of each product using ABC analysis.

Product Sales

The data is the data quantity of product sales that have been sold to customers in the period. The sales data can also be referred to as customer demand data. In managing inventory, the sales data is needed to determine the maximum level of inventory (S), which in turn is used to determine the order quantity (OQ) at the end of the inspection interval (R).

Review Interval (R)

Review interval (R) defined by Retail X is always the same, namely 1 week and ordering products are made at the end of each review interval (R).

Lead time (L)
Lead time (L) is the time range between ordering and the item purchased came to Retail X. In Retail X procurement made on Sunday at 21:30 pm, while product coming on Tuesday with a range of time between 7:00 to 10:00 pm. Under these conditions, it can be concluded that the lead time (L) is 2 days.

Holding Cost (Os)
Holding cost (Os) is a cost to be incurred by the company to keep the cost of the product and to ensure their product is safe when stored.

Shortage Cost (Ok)
The cost of inventory shortages or shortage cost is the cost incurred due to the absence of the goods when needed. Shortages can lead to backorder or lost sales. In Retail X, the inventory shortages can cause the lost sales. To find out the cost of shortages, the first thing to note is the expected number of each product shortages or Expected Shortage Per Replenishment Cycle (ESPRC).
Moreover, the other necessary data is the lost profits due to the lost sales of products. The average profit on a product set by the Retail X is 23% of the price. So the formulation for the shortage cost (Os) is:
= ESPRC * (23% * product price / unit)

Data Processing
Data processing is done after all the data involved in the calculation is obtained. Here are the steps of data processing for 2 proposed conditions and actual conditions:
1. Classifying the product using ABC analysis.
2. Calculating inventory policies covering safety stock calculations (SS), the maximum inventory level (S) and the order quantity (OQ) using R, S System in each condition.
3. Calculating the Inventory Total Cost (OT) in each condition.
4. Calculating the level of service in each condition.

Details of any data processing are as follows:

Inventory Policy calculations using Periodic-Review, Order-Up-to-Level (R,S) System
The calculation will be carried out in this study is the calculation of inventory policies on proposed condition 1, proposed condition 2 and actual condition. Once the inventory policy is established, it will determine the optimum inventory policies of the three conditions by looking at the resulting performance criteria. Here is a necessary component of the model used in the calculation of inventory policies-Periodic Review, Order-Up-to-level (R, S) System:
1. Performance Criteria
In determining the inventory policy on this research, the performance criteria objective function is to minimize the total inventory costs. Total cost of inventory (OT) is an accumulation shortage cost (Ok), holding cost (Os) and procurement cost (Op), so that the formulation becomes: OT = Op + Os + Ok.
2. Decision Variable
In this study, the inventory policy decision variables are:
- *Safety stock* (SS)
- Maximum inventory level (S)
- *Order quantity* (OQ)

Here is an example of inventory calculation policies for product A1 on the first R in December for Proposed Condition 1:

Calculation of Maximum Inventory Level (S)
Here is how to calculate the value of S for some types of products on proposed condition 1:

Table 1. The Calculation of S value in Proposed Condition 1

Pro-ducts	R+L (1)	□□ (2)	□□ R+L(3) = (1) x (2)	σ (4)	k (5)	SS (6) = (5) x (4) x akar (1)	S (7) = (3) + (6)
A1	0.3	110	33	13	1,65	12	45
A2	0.3	90	27	18	1,65	16	43
.							
A592	0.3	2	1	1	1,65	1	2
A593	0.3	0	0	1	1,65	1	1

Calculation of Order Quantity (OQ)
Here is how to calculate the value of OQ for some types of product on Proposed Conditions 1:

Table 2. The Calculation of OQ value in Proposed Condition 1

Code	IOH (1)	S (2)	OQ (3) = (2) - (1)
A1	12	45	33
A2	0	43	43
.			
A592	3	2	0
A593	4	1	0

Inventory Total Cost (OT) Calculation
Inventory total cost (OT) is an accumulation of shortage cost (Ok), holding cost (Os) and procurement cost (Op). So, to know the value of OT the cost of making up the OT should be calculated in advance. Here is the calculation of the total cost of inventory (OT) on Proposed Condition 1:

Holding Cost (Os) Calculation
Calculation of holding cost (Os) for product A1 on Proposed Condition 1 are as follows:

Table 3. Calculation of holding cost (Os) for product A1 on Proposed Condition 1

Product Code	Excess Inventory (1)	Holding Cost (Os) (2) = Rp29 x (1)
A1	20	Rp 580
A2	16	Rp 464
A592	2	Rp 58
A593	4	Rp 116
		Rp 103,936

So, the total holding cost (Os) on the first R in December for Proposed Condition 1 is Rp103, 936.

Procurement cost (Op) Calculation
There are two components of the procurement cost (Op) to be calculated, the cost of administration in every order (Op Component 1) and the cost of shipping from DC to Retail X (Op Component 2).

- Procurement cost (Op) component 1 Calculation

Op component 1 is the administrative costs incurred by the Retail X in each procurement. From the information by the Retail, it is known that the cost for order some product to DC is Rp50 for every procurement. This fee is the cost of sending purchase order by using internet services.

- Procurement cost (Op) component 2 Calculation

Op 2 is the cost of shipping the product from DC to Retail X. Shipping cost is determined by the DC by 2% of the total price of the product conducted by Retail X on every procurement. Total price is derived from the product of the price of the product / unit to the order quantity (OQ), so the calculation of total price is:

Table 4. Total price calculation in proposed condition 1

Product Code	Price (1)	*Order Quantity* (OQ) (2)	Total Price (3) = (1) x (2)
A1	Rp 11,457.00	33	Rp 378,081
A2	Rp 9,000.00	43	Rp 387,000
.			
A592	Rp 12,005.40	0	Rp -
A593	Rp 26,995.10	0	Rp -
			Rp 15,462,109

From Table 4 it can be seen that the total purchase price by Retail X on Proposed Condition 1 is Rp15, 462.109. Op component 2 is 2% of the total purchase price, so the calculation becomes:

Table 5. Calculation of procurement cost (op) component 2 on proposed condition 1

Condition	Total Purchase Price (1)	% Shipping cost (2)	Op 2 (3) = (1) x (2)
Proposed	Rp	2%	Rp

So the procurement cost components 2 for proposed condition 1 is Rp309, 242.

Total procurement cost is the accumulation of two procurement cost components.

Table 6. Calculation of total procurement cost (op) on proposed condition 1

Condition	Op Component 1 (1)	Op Component 2 (2)	Total Op (3) = (1) + (2)
Proposed Condition 1	Rp 50	Rp 309,242	Rp 309,292

Thus, the total cost of ordering (Op) for Proposed Condition 1 is Rp309, 292.

Shortage Cost (Ok) Calculation

The calculation of the shortage cost (Ok) for some types of products are as follows:

Table 7. Total shortage cost (ok) calculation proposed condition 1

Product Code	Price (1)	σ (2)	R+L (3)	ESPRC (4) = (2) x akar (3) x 0,0206	Shortage cost (5) = (4) x 23% x (1)
A1	Rp 11,457.00	13	0.3	0.147	Rp 387
A2	Rp 9,000.00	18	0.3	0.203	Rp 420
.					
.					
A592	Rp 12,005.40	1	0.3	0.011	Rp 31
A593	Rp 26,995.10	1	0.3	0.011	Rp 70
					Rp 40,329

From the calculation above, it can be seen that the total cost of the shortage on proposed Condition 1 is Rp40, 329.

Inventory Total Cost (OT) Calculation on Proposed Condition 1

Here is the calculation of OT for condition Proposal 1:

Table 8. total inventory cost (OT) for proposed condition 1

Condition	Os	Op	Ok	OT = (Os) + (Op) + (Ok)
Proposed Condition1	Rp 103,936.00	Rp 309,292.17	Rp 40,329.20	Rp 453,557.38

So the total inventory cost (OT) for proposed condition 1 is Rp453, 557.38.

Analysis of Choosing The Best Inventory Policy Based On Inventory Total Cost

The result of calculation inventory total cost in the first R in December for proposed condition 1 is Rp453, 557, on proposed condition 2 is Rp483, 323 and the actual conditions is Rp494, 505. Based on the results of these calculations, the cost saving that occur over both conditions are listed in the following table:

Table 9. Comparation of Inventory Total Cost (OT)

Condition	Os	Op	Ok	OT	Cost saving	%
Proposed Condition 1	103,936	309,292	40,329	453,557	40,948	8%
Proposed Condition 2	106,662	329,972	46,688	483,323	11,182	2%
Actual Condition	103,965	343,852	46,688	494,505		

Comparison of OT in graphical form for both proposed conditions and actual conditions are as follows:

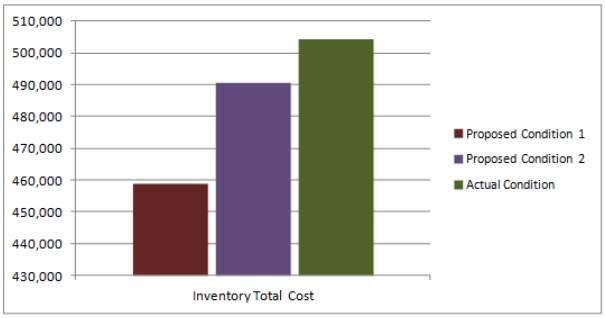

Figure 4. Comparation of Inventory Total Cost (OT)

Figure 4 shows that the total cost of the proposed Condition 1 is the minimum cost. Based on performance criteria (R, S) system which measures the stock performance over the total inventory cost, it can be ascertained that the inventory policy using the R, S system on the proposed condition 1 is the best inventory policy for Retail X.

Analysis of Implementation Proposed Condition Based on Service Level

After the implementation of the policy R, S system on two proposed conditions , it can be taken into account the possibility of out-of-stock is seen from the excess inventory at the first review interval in December. If the

excess inventory is 0, it can indicate that there is out-of-stock. So if there are more out of stock or more 0 inventory means it has a low service level. Here are the data products that have remaining stock 0 in each of these conditions:

Table 10. Amount of excess inventory

Product Type	Excess Inventory Proposed Condition 1	Excess Inventory Proposed Condition 2	Excess Inventory Actual Condition
A14	7	8	0
A30	0	0	14
A37	13	14	0
A38	15	19	0
A51	6	4	0
.			
A570	48	47	0
A571	11	9	0
A574	1	1	0
A587	9	8	0
A589	1	0	5
Amount of	**32**	**36**	**86**
Service Level	**95%**	**94%**	**85%**

In Table 10 it was found that the total types of products that had run out of stock by the end of December the first R is a total of 32 kinds of products for Proposed Condition 1, 36 kinds of products on Proposed Conditions 2 and 86 kinds of products on the Actual Conditions. From these values, the level of service can be calculated based on the type of products available to meet the customer. From the results of calculations it shows that the level of service for Proposed Condition 1 is at 95%, the proposed condition 2 by 94% and by 85% in actual conditions. Comparison of the level of service in the form of graphs for both conditions proposed and actual conditions are as follows:

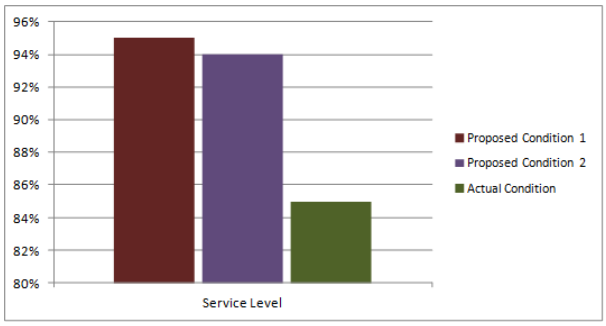

Figure 5. Service level comparison for 2 proposed condition and actual condition

From Figure 5 shows that proposed condition 1 has the highest service level that is equal to 95%, whereas the proposed condition 2 is 94%, and the Actual Conditions is 84%. Therefore, it can be ensured that the implementation of inventory policies using the R, S system on the proposed condition 1 is the most appropriate policy for the Retail X.

5. CONCLUSION

Based on the results of calculation data in this research, it can be concluded that the optimal inventory policies occurred during the implementation of Periodic-Review, Order-Up-to-level (R, S) System under proposed condition 1, the inventory policy details are as follows:

1. The amount of safety stock (SS) for product A1 is 12 units.
2. The maximum inventory level (S) for product A1 is 45 units.
3. Order quantity (OQ) for product A1 is 33 units.

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