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INVENTORY CONTROL SYSTEM ANALYSIS OF GOODS AT COMPANY X'S MODERN TRADE

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ABSTRACT

COMPANY X is a company that engaged in the field of consumer goods .The products' sales distribution is divided into general trade and modern trade. The company used a third party for the modern trade, namely COMPANY Y as a provider of warehouse and delivery service.

The existence of an uncertainty demand and the provision of consumer that the products received is the products that have expired remaining terms of over 5 months, cause the company has to control the inventory well. Currently the company ordering every 10 days and the amount is half of every month's forecasting results. Forecasting method used is the 3-period moving average. Company inventory control method has yet noticed the inventory in the warehouse so there is often shortage and excess goods in the warehouse.

In solving these problems will be calculated the maximum inventory and the inventory control method using periodic review (the value of t from 3 days to 10 days). All of these methods will be made in the simulation model by using Promodel as simulation software.

Based on simulation results, the total cost for the company's method is Rp. 2,101,485,010, the periodic review method with t=3 days (based on the smallest inventory control cost) is Rp. 1,904,376,880 (9.38 % savings), and the periodic review method with t = 10 days (based on the company's ordering period) is Rp. 1,934,429,650 (7.59 % savings). Therefore, the inventory control method that should be applied by the company is the periodic review method (t=3 days). However, if the company needs time to make changes, it may choose the periodic review method with the company's ordering period namely t=10 days.

Keywords*: consumer goods, inventory control, simulation*

1. INTRODUCTION

1.1 Problem Identification

COMPANY X is a company engaged in the field of consumer goods. The products produced are snacks, chocolates, candies, wafers and beverages. The products' sales distribution is divided into general trade and modern trade. General trade is a trade that is devoted to addressing traditional markets. General trade's sales method is performed by distributor. Modern trade is a trade that is devoted to addressing modern markets. Modern trade's sales method is direct selling means selling products directly to the store without going through a distributor. However, COMPANY X using third party logistics to shipping goods, namely COMPANY Y. So, COMPANY Y provides a warehouse only for COMPANY X's storage and transport for the delivery of goods to the store. Part which will be the object of study is a modern trade.

The ordering process from company to consumers is made the purchase order (PO). If the company cannot meet the demand, then company would have lost sales costs. If the shortage is less than a service level, then company will experience a service penalty costs. In addition, the company also must pay attention to the expired period of the products where the consumer is not willing to accept the goods with expired period is under the remaining term of 5 months. If the product has passed the expiration period, the product will be returned to the central warehouse. This would be very detriment to the company.

In addition, uncertainty demand causes the company often have excess and shortage goods so that the company will have a loss. Therefore, the company should be able to control the inventory in the warehouse well so there is no shortage and there is no excess.

In this research, inventory control method is proposed to minimize the total inventory costs.

2. THEORETICAL BACKGROUND

2.1. Forecasting

Forecasting is concerned with predicting the future. Forecasts can be based on a combination of an extrapolation of what has been observed in the past (what we call statistical forecasting) and informed judgements about future events. Informed judgements can include knowledge of firm orders from external customers, pre-planned shipments between location within a single organization, or preplanned usage of service parts in preventive maintenace. They also in include marketing judgements, such as the effects of promotions, competitor reactions, general economic conditions, and so on. (Silver, 1998)

2.1.1. Moving Average Method

The moving average model tracks the changing movement of the variable of interest as a function of its prior level. (Elsayed, 1994)

$$M_t = \frac{x_t + x_{t-1} + \cdots + x_{t-N+1}}{N} \quad (1)$$

where:
x_t = Actual demand in t period
N = Number of periods included in the moving average

2.2. Inventory System

Inventory is the raw material, semifinished parts and assemblies, and finished goods that are in the production system at any point in time. Inventories serve as a buffer between stages of the production system and between the production system and its customers.

The main objective of the analysis of an inventory sustem is to find the answers to the following two questions(Elsayed, 1994):

1. How much should be ordered (or produced)?
2. When should the orders be placed such that the total inventory costs are minimized?

2.2.1. Periodic Review Inventory Control System

The baseline characteristics of Periodic Review Inventory control method is: (Silver, 1998)

1. Ordering is done according to a fixed time interval (t).
2. Order quantity is the difference between the maximum inventories (E) with the existing inventory at the time the order is done.

Assumptions used in the Periodic Review Inventory control method is as follows:

1. Demand during the planning horizon is probabilistic.
2. Time between ordering (t) is constant for each time of ordering, the products will arrive simultaneously with Lead Time (L).
3. The unit cost of the item is constant independent of the quantity.
4. The ordering cost is constant for each time ordering
5. The carrying cost is comparable with the product price and storage time.
6. The cost of each backorder is independent of the length of time for which the backorder exists.

Calculation steps for Periodic Review Inventory control method is as follows:

1. Calculate $t = \sqrt{\frac{2C}{RH}}$ (2)

   If the order is made for certain types of items at once to the same supplier, then the calculation of t:

   $$t = \sqrt{\frac{2(C+nc)}{F\sum_{i=1}^{n}(P_i R_i)}} \quad (3)$$

2. Calculate F'(k)

   $$F'(k) = \frac{Ht}{\pi} \text{ (back order case)} \quad (4)$$

   $$F'(k) = \frac{Ht}{Ht+\pi} \text{ (lost sales case)} \quad (5)$$

3. Find the value of k from the normal distribution table based on the value of F'(k).
4. Calculate $E = \mu_{L+t} + K\sigma_{L+t}$ (6)

   where:

   $\mu_{L+t} = R(L+t)$ *dan* $\tau_{L+t} = \tau\sqrt{L+t}$

K is a decision variable which can be selected to achieve the desired results in terms of frequency of occurrence of stock out or service level of the consumer i.e. the value of K varies from 0 to 4.
F (K) is the probability that the demand is less than or equal to the reorder point.
F '(K) is the probability that demand during lead time will be equal to or greater than the point of ordering. F '(K) = 1 - F (K). (Smith, 1989)

3. RESEARCH METHOD

Figure 4 shows the research methodology flowchart.

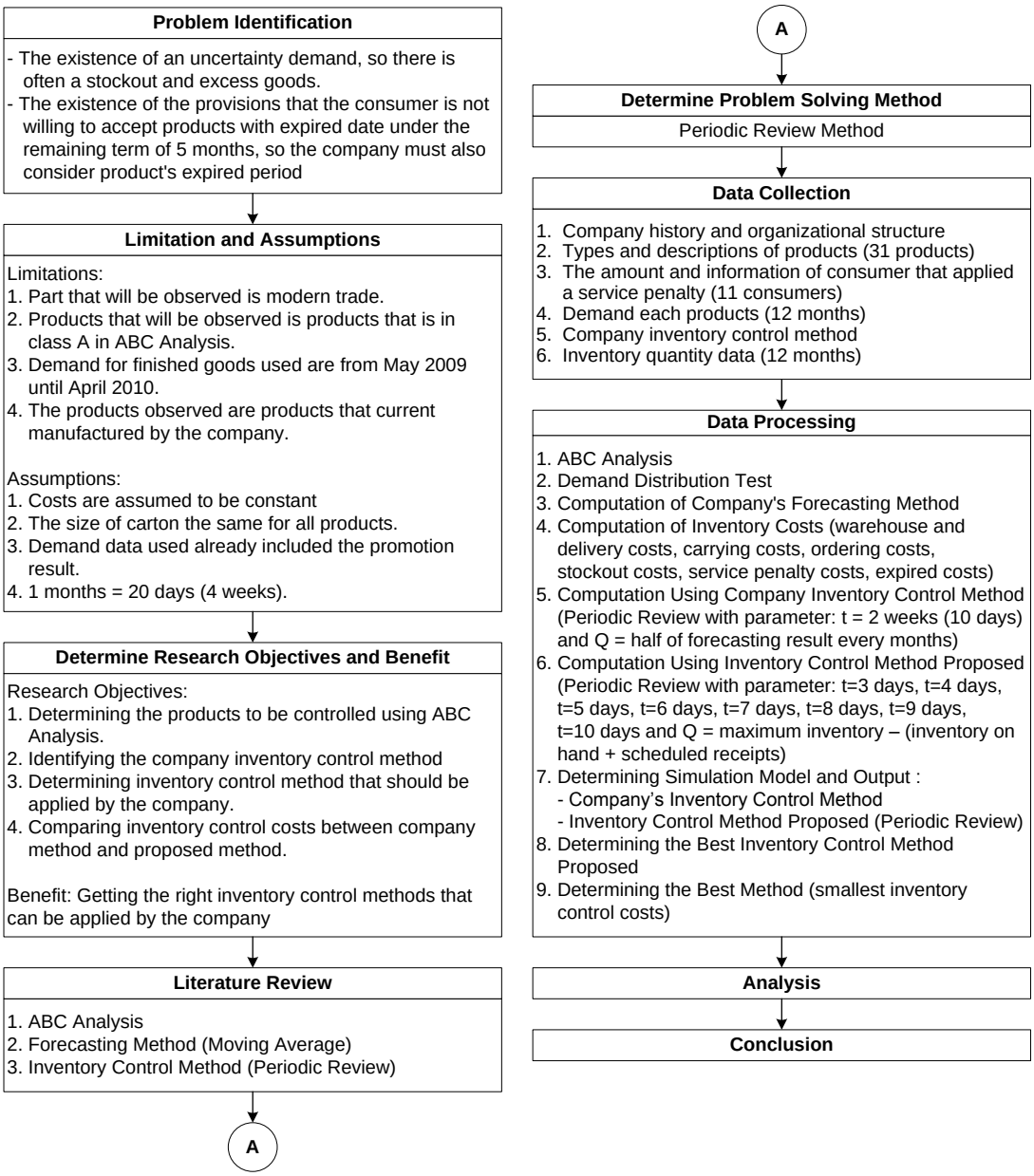

Figure 4. Research Methodology Flowchart

4. RESULT AND DISCUSSION

4.1. ABC Analysis

ABC Analysis is used to determine the priority control of inventory. The test is divided into three classes, namely A class (20% of the items or 80% of the total usage), B class (30% of the items or 15% of the total usage) and C class (50% of items or 5% of the total usage).

The company's product categories are divided into fast-moving and slow-moving products. Fast moving products often have stock out and excess, while the slow-moving products tend to be problematic to the expired period.

When seen from the demand quantity in the ABC Analysis, fast moving products tend to be in A class and slow-moving products tend to be in C class. Therefore, the priority for the controlled product is a product in the A class.

Based on the ABC Analysis, there are 10 products that belong to A class. There are PIS50, CTL360, PIB50, CTA360, SCL40, CTC360, RCC70, SCP40, PIK50, and DYC50.

4.2. Demand Distribution Test

Demand distribution test is intended to test whether the demand used is follow a normal distribution or not. The data will be tested using the Kolmogorov Smirnov (ks) test. If the value of ks stat on the test is smaller than the value of ks stat (12.5e-0002), then the results of statfit is do not reject that means the data follow a normal distribution.

Based on the demand distribution test, it was concluded that all the products are observed normal distribution. Mean value and standard deviation value obtained will be used to determine the demand quantity in the simulation model.

4.3. COMPANY X's Forecasting Method

Forecasting method is only used for company's inventory control. The company forecast the demand to determine the order quantity (Q). Order quantity is determined by a half of the forecasting results every month. The method used by company is a 3 period moving average (MA-3). This method is used because the company wants to see clearly the pattern of the data existing demand. The products produced by this company have a expired period. Therefore, the company noticed that a good forecasting method to use is short-term forecasting. Thus, companies can minimize deterioration that can occur and the results obtained will be more accurate.

4.4. Inventory Control Used by COMPANY X

Inventory control method used by the company is similar to periodic review in which the order is made every fixed time interval. The parameter values of t (ordering period) and Q (order quantity) is determined by the policy of the company.

In simulation modeling, there is a arrival function. This function is filled by the arrival of a review period and demand at the warehouse office. Review was performed to determine the order quantity (Q) to be ordered to the central warehouse. Ordering period is done every 10 days. Order quantity (Q) for a 10 days period is equal to half of the forecasting results every month. In this case the company uses a forecasting method with 3 period moving average (MA-3). Forecasting is done for each month based on demand from the previous 3 months. So, in 1 month the company ordering 2 times with the same quantity. For the first month forecasting results will be calculated using a formula. As for the next period forecasting will use the array function to continuously renew the demand that occurs in every month. The company orders all products simultaneously.

After the review, the order quantity is obtain and to be carried out. After that, the order is released to the central warehouse with one day lead time. With the information of the goods (from the central warehouse) in the office of the warehouse, the delivery initiated after an order is released.

Monthly demand (20 days) is modeled daily. Therefore the dynamic become smoother. The demand quantity follows a normal distribution.

The capacity of the company warehouse is capable of storing as many as 20,000 units (cartons). The calculation of E (maximum inventory) for each product is determined by the percentage usage value (total sales) multiplied the warehouse maximum capacity, so that the capacity of the warehouse in location function is modeled by maximum inventory for each product.

The calculation results of the company's maximum inventory can be seen in Table 1.

Table 1 COMPANY X's Maximum Inventory

Product	% Total Sales	Maximum Inventory (carton)
PIS50	15	3,000
CTL360	9.39	1,878
PIB50	9	1,800
CTA360	8.52	1,704
SCL40	8.33	1,666
CTC360	5.94	1,188
RCC70	5.87	1,174
SCP40	5.61	1,122
PIK50	5.46	1,092
DYC50	4.56	912

If the demand is greater than the inventory, the quantity delivered is equal to the inventory quantity in the warehouse, that will cause the lost sales costs and service penalty costs (if it does not meet the specified service level that is 82.86 %). If otherwise, then the quantity is equal to demand.

The company also noticed the expired period of each product. Consumers do not want the products that have expired remaining terms under 5 months. Based on the information obtained from the company, the average period of the goods stored in the central warehouse is half a month. So, for a product with an expired period of 8 months may only be kept for 2.5 months, whereas for products with expired period of 12 months may only be kept for 6.5 months. If the products stored exceeding the time limit, then the product is sent back to the central warehouse. The inspection in the simulation model will be done every day. In the simulation model is also used warm-up function period that is the period during which existing conditions start stabilized (steady state) that is for 6 months. Warm-up period is determined by performing simulations in advance with the 1 year data (240 days). From the simulation results, obtained the graph of the inventory quantity in the warehouse, so it can be determined the period in which the warehouse conditions start stabilized.

Based on simulation, obtained output results for company's inventory control, that can be seen in Table 3.

Table 3. Output results for company's inventory control

Product	*Output*								
	Order Frequency (times/year)	Ordering Costs (Rp./year)	Quantity of Lost Sales (carton/year)	Lost Sales Costs (Rp./year)	Service Penalty Costs (Rp./year)	Quantity of Expired (carton/year)	Expired Costs (year)	Warehouse and Delivery Costs (Rp./year)	Carrying Costs (Rp./year)
PIS50	24	54,050	72	1,352,860	153,070	0	0	345,155,610	0
CTL360			4,239	42,686,100	2,309,650	0	0	188,003,760	0
PIB50			0	0	0	0	0	274,742,000	0
CTA360			4,168	41,971,100	2,184,420	0	0	176,145,400	0
SCL40			1,138	21,382,700	1,109,780	0	0	203,502,460	0
CTC360			8,965	90,276,200	4,571,740	0	0	140,182,860	0
RCC70			365	7,546,910	464,960	0	0	138,381,630	0
SCP40			210	3,945,840	292,300	0	0	131,785,650	0
PIK50			37	695,210	56,180	0	0	136,813,390	0
DYC50			1,416	23,987,800	1,036,540	0	0	93,280,840	0
Total	**24**	**54,050**	**20,610**	**233,844,720**	**12,178,640**	**0**	**0**	**1,827,993,600**	**0**

The total cost incurred by using company's method is Rp. 2,101,485,010. From the simulation results, it can be seen that there is lost sales costs and service penalty costs that are quite substantial. The lost sales costs can occur due to an imbalance between the ordering period with the ordering quantity, which means that the method of determining the order quantity are not able to control demand during the ordering period. This is because the company pays less attention to the inventory quantity in the warehouse. The company's inability to meet the demand also result in a service penalty costs, where if the fulfillment percentage is below 82.86% the company must pay a penalty costs equal to 1% of total sales.

4.5. Inventory Control Using Periodic Review

Inventory control method proposed is periodic review method.

Based on calculations, is obtained parameters of the proposed inventory control method. Parameters of the proposed inventory control method can be seen in table 2.

Table 2. Parameters of the proposed inventory control method (periodic review)

Product	Periodic Review															
	t	E	t	E	t	E	t	E	t	E	t	E	t	E	t	E
PIS50	3 days	0	4 days	0	5 days	0	6 days	0	7 days	0	8 days	0	9 days	0	10 days	0
CTL360	3 days	1,290	4 days	1,515	5 days	1,734	6 days	1,949	7 days	2,160	8 days	2,368	9 days	2,574	10 days	2,778
PIB50	3 days	1,808	4 days	2,095	5 days	2,371	6 days	2,641	7 days	2,904	8 days	3,163	9 days	3,418	10 days	3,669
CTA360	3 days	828	4 days	967	5 days	1,102	6 days	1,234	7 days	1,364	8 days	1,492	9 days	1,618	10 days	1,742
SCL40	3 days	1,630	4 days	1,890	5 days	2,140	6 days	2,384	7 days	2,622	8 days	2,856	9 days	3,087	10 days	3,314
CTC360	3 days	1,205	4 days	1,369	5 days	1,525	6 days	1,674	7 days	1,819	8 days	1,960	9 days	2,097	10 days	2,232
RCC70	3 days	1,488	4 days	1,697	5 days	1,897	6 days	2,089	7 days	2,275	8 days	2,456	9 days	2,634	10 days	2,808
SCP40	3 days	596	4 days	687	5 days	774	6 days	859	7 days	942	8 days	1,023	9 days	1,102	10 days	1,181
PIK50	3 days	625	4 days	720	5 days	812	6 days	901	7 days	988	8 days	1,073	9 days	1,157	10 days	1,240
DYC50	3 days	531	4 days	618	5 days	702	6 days	784	7 days	864	8 days	943	9 days	1,021	10 days	1,098
TOTAL		**10,002**		**11,558**		**13,057**		**14,514**		**15,938**		**17,334**		**18,708**		**20,062**

where: E is maximum inventory

In this method, the arrival function filled with the arrival of a review (inspection) and demand at the warehouse office. Review (inspection) is done to determine how many order quantity (Q) to be ordered to the central warehouse. T value used is t=3 days, t=4 days, t=5 days, t=6 days, t=7 days, t=8 days, t=9 days, and t=10 days.

Based on model output, the results show the optimal value of t. Order quantity (Q) in the proposed method is determined based on the difference between the maximum inventory with inventory level in the warehouse at that time.

The order is sent to the central warehouse for 1 day lead time. The delivery of goods will be initiated after an order reveal.

Monthly (20 days) estimated demand will be modeled daily. The demand quantity follow a normal distribution..

The maximum inventory for each product has been determined previously. So the maximum inventory will vary according to the value of period (t) used.

If the demand is greater than the inventory, the quantity delivered is equal to the inventory quantity in the warehouse, that will cause the lost sales costs and service penalty (if it does not meet the specified service level). If otherwise, then the quantity is equal to demand.

The company also noticed the expired period of each product. Consumers do not accept the products that have expired date under 5 months. Based on the data obtained from the company, the average period of the goods stored in the central warehouse is a half month. So, for a product with an expired period of 8 months may only be kept for 2.5 months, whereas for products with expired period of 12 months may only be kept for 6.5 months. If the products stored exceeding the time limit, then the product is sent back to the central warehouse.

The model warm-up period is 6 months, after that the model show the real system situation and behavior and also reach steady state. Warm-up period is determined by performing simulations in advance with the 1 year data (240 days). From the simulation results, obtained the graph of the inventory quantity in the warehouse, so it can be determined the period in which the warehouse conditions start stabilized.

Based on the simulation model, the output results for periodic review inventory control method, that can be seen in Table 4.

4.6. Determining Proposed Inventory Control Method

Based on the output results, it can be seen the total cost of each inventory control methods. From the comparison of the inventory control total cost, will be determined the proposed method. This determination is based on the smallest total costs and the equal ordering period with the company. The comparison of the total costs for the proposed inventory control methods (periodic review) can be seen in Table 5.

Table 4. Output rresult for periodic review inventory control method (t = 3 days and t = 10 days)

t	Produk	Ouput								
		Order Frequency (times/year)	Ordering Costs (Rp./year)	Quantity of Lost Sales (carton/year)	Lost Sales Costs (Rp./year)	Service Penalty Costs (Rp./year)	Quantity of Expired (carton/year)	Expired Costs (year)	Warehouse and Delivery Costs (Rp./year)	Carrying Costs (Rp./year)
3 days	PIS50	80	180,180	0	0	0	0	0	344,077,000	0
	CTL360			0	0	0	0	0	194,876,100	0
	PIB50			0	0	0	0	0	273,696,000	0
	CTA360			0	0	0	0	0	181,174,500	0
	SCL40			0	0	0	0	0	205,260,000	0
	CTC360			0	0	0	0	0	160,238,000	0
	RCC70			0	0	0	0	0	140,025,700	0
	SCP40			0	0	0	0	0	133,796,700	0
	PIK50			0	0	0	0	0	136,687,200	0
	DYC50			0	0	0	0	0	101,047,500	0
	Total	**80**	**180,180**	**0**	**0**	**0**	**0**	**0**	**1,870,878,700**	**0**
10 days	PIS50	24	54,050	0	0	0	0	0	344,419,000	0
	CTL360			0	0	0	0	0	194,464,100	0
	PIB50			0	0	0	0	0	274,209,000	0
	CTA360			0	0	0	0	0	182,793,300	0
	SCL40			0	0	0	0	0	205,973,000	0
	CTC360			0	0	0	0	0	161,368,200	0
	RCC70			0	0	0	0	0	139,900,300	0
	SCP40			0	0	0	0	0	133,739,700	0
	PIK50			0	0	0	0	0	136,943,700	0
	DYC50			0	0	0	0	0	100,225,300	0
	Total	**24**	**54,050**	**0**	**0**	**0**	**0**	**0**	**1,874,035,600**	**0**

Table 5. Comparison of the inventory control total costs for each value of t

Periodic Review Method	Total Costs (Rp./year)
t = 3 hari	1,904,376,880
t = 4 hari	1,909,166,440
t = 5 hari	1,913,700,510
t = 6 hari	1,918,126,090
t = 7 hari	1,941,259,380
t = 8 hari	1,926,467,380
t = 9 hari	1,905,855,160
t = 10 hari	1,934,429,650

In Table 5, it can be seen that the proposed inventory control method that provides the smallest total cost is a periodic review inventory control method with a value of t=3 days (Rp. 1, 904,376,880). Periodic review method with a value of t=10 days (Rp. 1,934,429,650) will also be proposed method because ordering period used by the company is t=10 days. So, the total costs from the proposed methods can be compared with the total cost from company's method.

4.7. Determining Best Inventory Control Method

In the previous section, obtained inventory control method proposed that is periodic review inventory control with the value t=3 days and t=10 days. This method will be compared with the company's inventory control methods.

The comparison of total costs between company's inventory control method and the proposed inventory control methods can be seen in Table 6.

Table 6. The comparison of the total cost between company's inventory control method and the proposed inventory control methods

Cost Type	Method		
	PT. X	Periodic review (t=3 days)	Periodic review (t=10 days)
Warehouse and Delivery Costs	1,827,993,600	1,870,878,700	1,874,035,600
Carrying Costs	27,414,000	33,318,000	60,340,000
Ordering Costs	54,050	108,110	54,050
Lost Sales Costs	233,844,720	0	0
Service Penalty Costs	12,178,640	0	0
Expired Costs	0	0	0
Total Costs	2,101,485,010	1,904,304,810	1,934,429,650

The total costs is calculated based on the value of the warehouse and delivery cost, the carrying cost, ordering cost, lost sales cost, service penalty cost, and expired cost. Based on simulation results, obtained the total cost of the proposed inventory control methods with t=3 days is Rp. 1,904,376,880 and t=10 days is Rp. 1,934,429,650 while for company's inventory control methods is Rp. 2,101,485,010.

From these results, it can be seen the inventory control method that has the smallest total cost is a periodic review method with t=3 days. Therefore, the company should implement this method by speed up the ordering period because this method provides greater savings (9.38 %)

compared to the periodic review method with t=10 days (7.95 %). But if the company cannot quickly implement a new change, then the company can choose the periodic review method with the equal t value which is 10 days by using the parameters used.
Parameters of the periodic review method with t=3 days can be seen in Table 8.

Table 8. Parameters of the periodic review method with t=3 days

Product	Maximum Inventory (E)	
	t = 3 days	t = 10 days
PIS50	1,291	2,779
CTL360	1,809	3,669
PIB50	828	1,743
CTA360	1,631	3,315
SCL40	1,206	2,232
CTC360	1,489	2,808
RCC70	596	1,181
SCP40	625	1,240
PIK50	532	1,098
DYC50	718	1,335
Total	**10,725**	**21,400**

5. CONCLUSION

1. Products that should be prioritized for control are products that belongs to A class of ABC classification. There are PIS50, CTL360, PIB50, CTA360, SCL40, CTC360, RCC70, SCP40, PIK50, and DYC50.
2. Inventory control methods applied by the company at this time similar to the Periodic Review where companies make orders to the central warehouse twice in a month. Order quantity is half of forecasting quantity every month. Forecasting method used is the 3 period moving average (MA-3).
   Currently, in determining the order quantity the company has not noticed the inventory in the warehouse. Consequently, the company earned a lost sales cost of Rp. 233,844,720 per year and the service penalty cost of Rp. 12,178,640 per year. Total cost of the company's inventory control method is Rp. 2,101,485,010 per year.
3. Inventory control methods that should be applied by the company is periodic review in which the order is done once every 3 days.
   But if the company cannot quickly implement a new change, the company can make a gradual change by applying the method proposed periodic review inventory control with the equal t value is 10 days. The total cost for t=3 days is Rp. 1,904,376,880 and t=10 days is Rp. 1,934,429,650.
4. The savings that can be obtained when applying the inventory control method proposed are Rp. 197,108,130 (9.38%) for t=3 days and Rp. 167,055,360 (7.95%) for t=10 days.

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