The Optimization of Inventory Control for Two-Seasons Demand and Known Price Increase

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Abstract.PT X is one of the raincoats factories located in Central Java, Indonesia. At this time, PT X does not have a good inventory system because it is still based on intuition. This makes stock-out often exists causing the loss of sale. PT X wants to minimize its inventory costs. Demand in PT X is divided into two periods of demand, which is high season and low season. Low season demand period occurs from February until July and high season demand occurs from August until January. PT X experiences the price increase for the material on August 2014. When the price increase is known, a policy can be taken to do a special order. At this time, PT X determines the number of the special order intuitively. We modify the known price increase model to accommodate the demand which is divided into two periods. In this method, the number of special orders is determined to produce the optimum savings. Several studies have been conducted related to the price increase problem, but no consideration is taken for the two seasons demand

Keywords: Optimization of Inventory Control, Known Priced Increase

1. INTRODUCTION

Inventory is one important part in the production activities. Inventory is the material held in an idle or incomplete state awaiting future sale, use, or transformation. Based on this, a company usually has an inventory of all materials, either in a state of waiting for the process, semi-finished and finished products that are awaiting further processing. In the daily activities, inventory sometimes experiences that the purchase price of raw materials will increase in the future and the time for the priced increase is also known. This situation may occur for one or more of the raw material. The previous study, Aritonang (2014),considered this situation, specifically for the priced increase for more than one raw material.The study was performed by considering that there is no seasoning of the use of the product.

PT X produces a raincoat. There are three different types of raincoats manufactured, namely jacket (JC), poncho (P), and a raincoat (RC). Each type of raincoat has also several types of products. There are 20 product types using different raw materials. The main raw material (plastics) used is supplied by two suppliers, i.e. ID and IN. For producing the 20 products the PT X used 41 plastic types of material.

The demand data of raw materials is taken since 2011 to 2014. The graph of the demand of raw materials is shown in Figure 1. The demand of raw materials has a pattern. At any given time, the demand will be either high or low. Therefore, the demand will be divided for high season and low season demand. High season demand is demand startsfrom August to January and low season demand is demand starts from February to July. After hypothesis testing, it is also concluded that data follow the normal distribution.In the low season demand there were only 30 kinds of plastic material needed for production. This is caused by the absence of demand for some types of products during the low season.

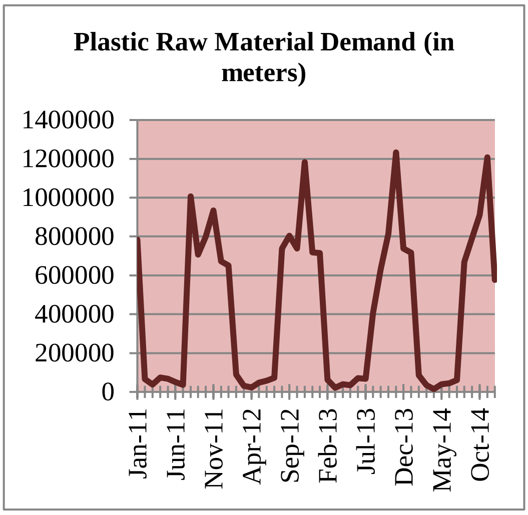

Figure 1: The graph of the demand of raw materials

2. THE INVENTORY SYSTEM MODEL

Known price increase is the condition when there will be price increases on future ordering. In this condition, the company will order a bigger amountbefore the price increase, therefore it is necessary to determine the amount to be purchasedrightly.

The amount of economic order quantity (Q*) used for the high season (Qh*) and for low season (Ql*) can be seen in equation 1 and 2. The amount of economic order quantity after the price increase for both periods can be seen in equation 3 and 4.

$$Q_h^* = \sqrt{\frac{2A\lambda_h}{CI}} \quad (1)$$

$$Q_l^* = \sqrt{\frac{2A\lambda_l}{CI}} \quad (2)$$

$$Q_{a_h^*} = Q_h^* \sqrt{\frac{C}{C+k}} \quad (3)$$

$$Q_{a_l^*} = Q_l^* \sqrt{\frac{C}{C+k}} \quad (4)$$

where:

Q_h^* : Economic Order Quantity (EOQ) for the High season

Q_l^* : Economic Order Quantity (EOQ) for Low season

Qa_h^* : EOQ after the price increase for the High season

Qa_l^* : EOQ after the price increase for the Low season

λ_h : Demandfor the High season

λ_l : Demandfor the Low season

I : Holding cost fraction

k: the value of the price increase

C : cost per unit

Assuming the amount of the lead-time is zero, the model of the inventory when the price increases and a special order is performed, can be seen in the following Figure 2.

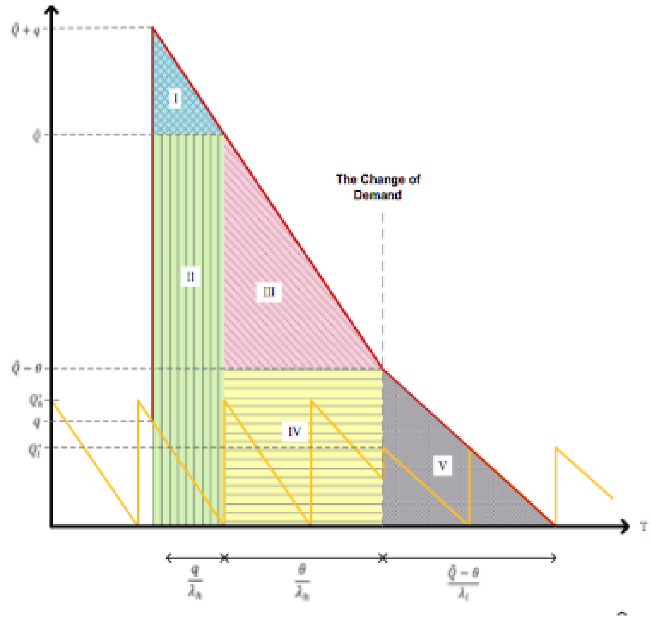

Figure 2:Known Price Increase model with special Order $\hat{Q}$

It can be calculated the total cost when the special order is performed(TCs). When inventories are at the q unit, the price is increased by value k and a special orders $\hat{Q}$ is performed.The purchasing cost is the multiplication of the value of $\hat{Q}$ with the cost per unit (C). The ordering cost is A. The holding cost comprises into five areas, i.e., area I, area II , area III, area IV, and the area V, as shown in Figure 2.

The following is the way to calculate the holding cost; at the time the order comes, q units (the inventory position when the price increase) will be used for the period $\frac{q}{\lambda_h}$, then the holding cost for the area I is $\left(CI\frac{q}{2}.\frac{q}{\lambda_h}\right)$. During the use of q, the $\hat{Q}$ is kept in the inventory, so the holding cost for area II is $\left(CI\hat{Q}.\frac{q}{\lambda_h}\right)$. After q finish, part of $\hat{Q}$ will be used by θ for the period $\frac{\theta}{\lambda_h}$, then for the holding cost area III is equal to $\left(CI\frac{\theta}{2}.\frac{\theta}{\lambda_h}\right)$. It can be said that θ is amount of demand after the q finish until the period demand change. After the use of θ, the number $(\hat{Q}-\theta)$ is the rest of inventory that will be used after the change of demand. Then the holding cost for the area IV is $\left(CI(\hat{Q}-\theta).\frac{\theta}{\lambda_h}\right)$. On entering the period of low season demand, the inventories of $(\hat{Q}-\theta)$ is used for the period of $\frac{(\hat{Q}-\theta)}{\lambda_l}$, then the holding cost for the area V is $\left(CI\frac{(\hat{Q}-\theta)}{2}.\frac{(\hat{Q}-\theta)}{\lambda_l}\right)$. The total cost when the special order is performed (TC_S) can be seen in the following equation;

$$TC_s = C\hat{Q} + \frac{Cfq^2}{2\lambda_h} + \frac{Cfq\hat{Q}}{\lambda_h} + \frac{Cf(\hat{Q}-\theta)\theta}{\lambda_h} + \frac{Cf(\hat{Q}-\theta)^2}{2\lambda_l} + A \qquad (5)$$

If there is no a special order is performed, the inventory model can be seen in the following Figure 3.

The amount of the purchase cost is equal to $((C+k)\hat{Q})$. The ordering cost is made for both a period of high season demand and low season demand. For the period of high season, the ordering number is equal to $\frac{\theta}{Qa_h^*}$ and in the

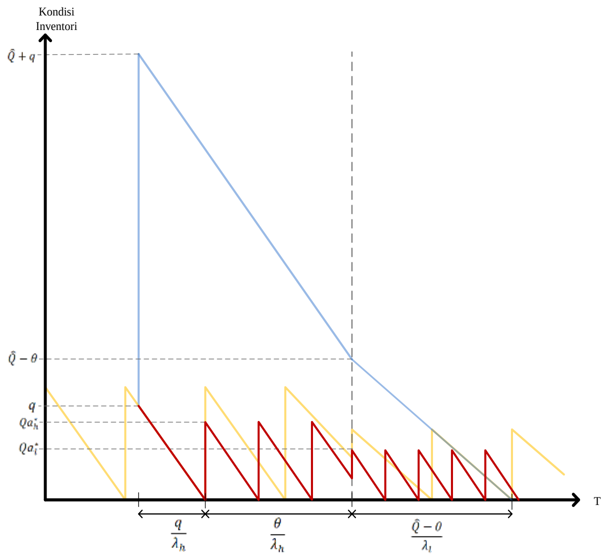

Figure3:Known Price Increase model with no special order

low season, the ordering number is $\frac{\hat{Q}-\theta}{Qa_l^*}$. The holding cost when no special order is divided into three parts, the first is in finishing q, the second is the use of inventory until the period is changed, and third is the inventory during periods of low season. For the first part, the holding cost is is $\left(C.I.\frac{q}{2}.\frac{q}{\lambda_h}\right)$, for the second part, the holding cost is $\left((C+k).I.\frac{Qa_h^*}{2}.\frac{\theta}{\lambda_h}\right)$ and for the the third part, the holding cost is $\left((C+k).I.\frac{Qa_l^*}{2}.\frac{\hat{Q}-\theta}{\lambda_l}\right)$. Then the total cost if no special order(TC_n) can be calculated by the following equation;

$$TC_n = (C+k)\hat{Q} + \frac{CIq^2}{2\lambda_h} + \frac{(C+k)IQ_{a_h^*}\theta}{2\lambda_h} + \frac{(C+k)IQ_{a_l^*}(\hat{Q}-\theta)}{2\lambda_l} + \left(\frac{\theta}{Q_{a_h^*}} + \frac{\hat{Q}-\theta}{Q_{a_l^*}}\right)A \qquad (6)$$

Next, we calculated the amount of saving (g) if the special order is performed by subtracting TC_n with TC_S. The result is given on equation 7.To obtain the optimal value of$\hat{Q}$ (written as$\hat{Q}^*$), the equation g will be derived to $\hat{Q}$ and set them equal to zero, then equation 8 is found.

$$g = (C+k)\hat{Q} + \frac{CIq^2}{2\lambda_h} + \frac{(C+k)IQ_{a_h^*}\theta}{\lambda_h} + \frac{(C+k)IQ_{a_l^*}(\hat{Q}-\theta)}{\lambda_l} - (C\hat{Q} + \frac{CIq^2}{2\lambda_h} + \frac{CIq\hat{Q}}{\lambda_h} + \frac{CI\theta^2}{2\lambda_h} + \frac{CI(\hat{Q}-\theta)\theta}{\lambda_l} + \frac{CI(\hat{Q}-\theta)^2}{2\lambda_l} + A \quad (7)$$

$$\hat{Q}^* = \frac{k\lambda_h\lambda_l + IQ_{a_l^*}\lambda_h(C+k) - CIq\lambda_l - CI\theta\lambda_l + CI\theta\lambda_h}{CI\lambda_h} \quad (8)$$

Then $\hat{Q}^*$ is the number special order that can maximize the saving g. This formula is used to determine the number of special order when there exists a known price increase situation for the material supplied by a supplier.

3. APPLICATION OF THE MODEL

PT X has experienced of this price increase for the supplier IN, where the price is increased by 10% in August 2014. By using this method, PT X can estimate the amount to be ordered to anticipate the price increase. These amounts will provide savings to the company.The Calculation begins by determining the values of Q_h^*, Q_l^*, Qa_h^*, and Qa_l^*. The calculation is performed for all type of plastics supplied by the IN supplier. The results can be seen in table Ion the appendix 1.For example, the calculations for plastics IN- 42 are as follows:

I. Determine the ordering cost (A = Rp 75,000.00), the purchase price before the price increase (C = Rp 3,465.00), price increases k (it was10 % of the purchase price), the holding fraction (I) , high season demand (λ_h= 26,591 m) and the low season demand (λ_l= 0).

II. Calculate the values ofQ_h^*andQ_l^*using the equation 1 and 2.

$$Q_h^* = \sqrt{\frac{2(75000)26{,}591}{(3465.5)(0.02)}} = 4706 \quad m$$

$$Q_l^* = \sqrt{\frac{2(75000)0}{(3465.5)(0.02)}} = 0 \quad m$$

III. Calculate the values ofQa_h^*, and Qa_l^*using the equation 3 and 4.

$$Qa_h^* = 4706.\sqrt{\frac{3465}{3465+347}} = 4487 \quad m$$

$$Qa_l^* = 0.\sqrt{\frac{3465}{3465+347}} = 0 \quad m$$

IV. To determine the value of θ, it is needed to specify the inventory position in warehouse (q) when performing a special order. This value will be used to calculate the magnitude of demand from the finished q until to the change point of the demand period. For example, for plastics of IN- 42, the calculation is as follows: When the special order is performed, it is found that q is 2,353 mand it will finish at 0.531 month ($\frac{2353m}{26591m/6 \ months}$).If the increase will occur in August (month 8th), it means that there are still five months to reach the change of the demand period in February. Then the value of θ can be calculated as follows:

$$\theta = (5 - 0{,}531 - \textit{lead time}).26.591\text{m}/(6\ ) = 4{,}23 \quad 26.591\text{m}/6 = 18.743 \ m.$$

V. Now the magnitude of $\hat{Q}^*$can be calculated by equation 8. If there is no demand on low season period, the value of $\hat{Q}^*$ is similar. Assuming that this calculation can only be applied if the use of $\hat{Q}^*$ can not be more than a period of low season demand. The values of TC_S, TC_n, and saving gare calculated and then presentedin Table 2 on the appendix 2. The saving*g*on IN-C11, C22-IN, and IN- C70 are negative, so there will not be a special order for all these three type of plastics

4. CONCLUSION

PT X is one of the raincoats factories located in Central Java, Indonesia.PT X faces the demand that divided into two periods, which is high seasonand low season. Sometimes PT X also experienced the price increase situation and they do not have a specific method that can be used to deal with this situation.A method was derived and used to this situation. This method has been modified to accommodate the demand, which is divided into two periods. In this method, the number of special order is determined to produce the optimum savings.

REFERENCES

Aritonang Kinley, Feronika (2012). Inventory Control of the Product For Special Sale Model. *Proceeding of 5th International Seminar on Industrial Engineering & management (5th ISIEM)*, Manado, Indonesia.

Aritonang Kinley, Sitompul, C.,and Alfian (2014). Implementation of Inventory System by P(R,T) model with Differenced Time Known Priced Increase at PT IntiVulkatama. *Proceeding of the 16th Asia Pasific Industrial Engineering and Management Systems Conference (16th APIEMS)*, Ho Chi Minh City.

Baker, R. C.,&Vilcassim, N. (1983). Continuous review price change inventory model. *Production and Inventory management*, 24(4), 67-72.

Blank, L.(1962). *Statistical Procedures for Engineering, Management, and Science*. Texas:McGraw-Hill International Book Company.

Chen, K. K., & Chang, C. T. (2007). A seasonal demand inventory model with variable leadtime and resource constraint. *Applied Mathematical Modelling*,31(11, 2433-2445.

Fogarty, D. W., Blackstone, and Thomas, R. H. (1991). *Production and Inventory Management*, 2nd Edition. Cincinnati: South Western Publishing

Gupta, Y., Sundararaghavan, P. S.,& Ahmed, M. U. (2003). Ordering Policies for items with seasonal demand. *International journal of Physical Distribution & Logistics Management*, 33(6), 500-518

Hadley, G. and Whitin, T. M. 1963.Analysis of Inventory Systems. London: Prentice Hall International.

Tersine, R., 1994. *Principle Of Inventory and Materials Management*, 4th edition, Prentice hall.

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Apendix 1

Table 1.The values of Q_h^*, Q_l^*, Qa_h^*, and Qa_l^*

Code	C (Rp)	K (Rp)	*High season* (m)				*Low season* (m)			
			λ_h	λ_h/month	Q_h*	Qa_h^*	λ_l	λ_l/month	Q_l*	Qa_l^*
IN-42	3465	347	26591	4431,833	4706	4487	0	0	0	0
IN-344	4240	424	17240,33	2873,389	3425	3266	763,6667	127,2778	721	332
IN-773	4240	424	17240,33	2873,389	3425	3266	763,6667	127,2778	721	332
IN-784	3540	354	26319	4386,5	4632	4417	0	0	0	0
IN-0A0	4070	407	306917	51152,83	14749	14063	13550,67	2258,444	3100	2897
IN-C03	7185	719	92797	15466,17	6104	5820	5678,667	946,4444	1510	1206
IN-C09	3530	353	109114,7	18185,78	9443	9004	0	0	0	0
IN-C11	3460	346	617,3333	102,8889	718	685	0	0	0	0
IN-C22	3460	346	617,3333	102,8889	718	685	0	0	0	0
IN-C3A	3460	346	90477	15079,5	8686	8282	0	0	0	0
IN-C70	3460	346	617,3333	102,8889	718	685	0	0	0	0
IN-C79	3460	346	109114,7	18185,78	9538	9095	0	0	0	0
IN-C89	5890	589	27612	4602	3678	3507	659,3333	109,8889	569	320
IN-C90	3460	346	109114,7	18185,78	9538	9095	0	0	0	0
IN-C95	5890	589	27612	4602	3678	3507	659,3333	109,8889	569	320

Appendix 2

Table 2.The values of$\widehat{Q}^*$, TC_s, TC_n, and g

Code	q (m)	q/λ_h	θ/λ_h	θ (m)	$\widehat{Q}^*$(m)	TC_n (Rp)	TC_s (Rp)	g (Rp)
IN-42	2353	0,531	4,23	18742,53	19807	76.139.967	70.230.954	5.909.013
IN-344	1713	0,596	4,16	11964,33	12728	59.939.657	55.266.752	4.672.906
IN-773	1713	0,596	4,16	11964,33	12728	59.939.657	55.266.752	4.672.906
IN-784	2316	0,528	4,23	18563,74	19617	77.038.201	71.060.846	5.977.355
IN-0A0	7375	0,144	4,62	236112,5	249664	1.120.346.573	1.036.937.556	83.409.017
IN-C03	3052	0,197	4,56	70566,95	76246	604.619.629	559.569.022	45.050.606
IN-C09	4722	0,260	4,50	81842,3	86207	336.124.180	310.723.313	25.400.867
IN-C11	359	3,489	1,27	130,7511	156	641.231	652.354	-11.124
IN-C22	359	3,489	1,27	130,7511	156	641.231	652.354	-11.124
IN-C3A	4343	0,288	4,47	67435,42	71055	271.675.763	251.079.261	20.596.502
IN-C70	359	3,489	1,27	130,7511	156	641.231	652.354	-11.124
IN-C79	4769	0,262	4,50	81795,3	86160	329.293.047	304.400.867	24.892.180
IN-C89	1839	0,400	4,36	20066,52	21164	137.997.828	127.414.672	10.583.156
IN-C90	4769	0,262	4,50	81795,3	86160	329.293.047	304.400.867	24.892.180
IN-C95	1839	0,400	4,36	20066,52	21164	137.997.828	127.414.672	10.583.156