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Inventory Control for Eyeglass Supply Using the P Model Based on Sales Products Sales Forecasting (Case Study: Merry Optic Bandung)

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Abstract

Inventory is a resource owned by the company to be used in the production process to meet consumer demand. Companies must be able to control inventory appropriately in order to avoid excess or shortage of inventory by using inventory control. Inventory control is a necessary part of a company that requires an appropriate inventory policy to meet uncertain needs. Based on this background, this study discusses the single item inventory model in the form of photochromic glasses at Merry Optik to find the optimal total inventory cost. In meeting the uncertain needs of the company, the Additive Decomposition forecasting method is used in order to find out the forecast sales data pattern in the future. Uncertain demand causes the inventory system to be probabilistic, so it is necessary to carry out probabilistic inventory control. The P model of the case of back orders was chosen because the range of ordering periods is fixed and the company can buy inventory when it runs out before the time the inventory order is made so that buyers can wait until the inventory arrives. By using Model P for the case of back orders, the company can obtain the period between orders, the total cost of inventory, and the optimal level of service. Based on the results of this study, a pattern of sales forecast data is obtained which repeats every 12 months. Companies must order glasses within a period of 32 days between orders so that it is optimal and able to provide a reduction in the total inventory cost of IDR 21,828,771 with a service level of 95%. Companies can save on inventory costs if they use shorter periods between orders. The total cost of inventory can be more optimal if the company reduces the cost of storing inventory in the warehouse.

Keywords: Probabilistics Inventory Control, Forecasting, Additive Decomposition Method, Model P

1. Introduction

Retail marketing or retail business is the activity of selling goods or services to individuals for their own needs. Retail marketing is effective marketing because it involves selling goods directly to end consumers so that consumers can get products quickly. The eyewear retail industry is developing rapidly in line with the development of technology in this digital age. This has resulted in greater competition in the eyewear business, resulting in more and more eyewear innovations

The existence of inventory, especially in a company, needs to be regulated in such a way as to produce the expected product at the minimum possible cost with optimal results both in terms of quantity and quality. In inventory control there must be a system for recording and counting inventory, because this affects financial reporting. Inventory system is a system used to manage inventory in the warehouse.Inventory information system is a system used to collect and maintain data that describes commodity inventories, transforms data into information and reports to users. The problem with companies that often occurs is that the demand for an item often changes every time.

Merry Optik is a company located at Jalan Nanjung KM 4, Margaasih District, Bandung City. Merry Optik is a company engaged in the optical industry, namely, a company engaged in the health sector that provides health services in the field of eyewear.Sales of glasses at Merry Optik change over time, sometimes increasing or decreasing and are expected to have seasonal influences. The inventory policy that needs to be carried out by Merry Optics is to use the P model with back order cases based on forecasts of eyeglass sales using the Additive Decomposition method.

Previous studies related to the method used by Fatma and Pulungan to analyze the condition of a company's inventory using the probabilistic inventory method, including simple probabilistic control, the P model, and the Q model. The result is that the P model provides the cost and amount of safety stock.

This problem can be solved by using forecasting methods to determine the amount of demand in the future, then it will be determined the appropriate product inventory policy based on the forecasting results. The state of the art in this research can be seen in Table 1.

Table 1: State of the art research

Researcher	Year	Title Article	Results
Erika Fatma and Dian Serena Pulungan	2018	Inventory control analysis using probabilistic methods with backorder and lost sales policies	Model P provides the optimal cost and amount of safety stock compared to other inventory models
Aurachman & Kenaka	2019	Determination of Inventory Periodic Review Policy (R, S, S) Using Power Approximation Method for Minimize Total Inventory Cost in PT. Opq	the total supply cost using periodic review policy (R,s,S) is IDR 936,061,349 or 15% lower than total cost with the existing condition
Esra Gökbayrak and Enis Kayış	2021	Single item periodic review inventory control with sales dependent stochastic return flows	the company uses returns as a second source of supply and thus limits the frequency of orders and reorders

Based on Table 1 and the problems above, the main discussion in this research is to combine the additive decomposition forecasting method with the P Model probabilistic inventory method with back order condition to solve inventory problems in Merry Optik.

2. Literature Review

2.1. Inventory Control

Inventory control is a series of control policies to determine inventory levels that must be maintained, when orders to increase inventory must be made, and how large orders must be held (Render et al., 2011).

2.2. Probabilistic Inventory Control Method

According to Render et al., (2011), a probabilistic inventory control method is an inventory model where conditions are not known with certainty, but the expected value, variance and distribution pattern can be predicted. The probabilistic inventory control policy is known by the existence of two methods, which are P Model and Q Model. The difference between the two models lies in the time of order.

2.3. P Model with Back Order Condition

P Model is a probabilistic inventory model related to the determination of operating stock and safety stock. In P Model, order time is the main parameter and the period between ordered orders is constant (Bakker, 2012). In a back order condition, when inventory is not available, the buyer wants to wait for the requested product until it is available in the warehouse and the company will make an emergency purchase. Cost formulations considered in inventory control include:

a) Purchase Cost (O_b)

$$O_b = D \cdot p \tag{1}$$

b) Order Cost (O_p)

$$O_p = f \cdot A \tag{2}$$

c) Holding Cost (O_s)

$$O_s = h \cdot m \tag{3}$$

d) Shortage Cost (O_k)

$$O_k = N_T \cdot c_u \tag{4}$$

The total inventory cost equation (O_T) is the sum of all inventory costs can be seen in equation 5.

$$O_T = O_b + O_p + O_s + O_k$$

$$O_T = D \cdot p + \frac{A}{T_0} + h\left(R - D_L - \frac{T_0 D}{2}\right) + \frac{c_u}{T_0} N \tag{5}$$

To get the inventory solution with the P Model with back order condition, the value needs to be minimized by determining the optimal value of and . To obtain this value, the Hadley-Within algorithm can be calculated in the following way (Bakker, 2012):

a) Calculate the initial value of T_0 with the Wilson Formula

$$T_0 = \sqrt{\frac{2A}{Dh}} \tag{6}$$

b) Next the value of the possible shortage of inventory a will be calculated and the value R will be calculated after

$$a = \frac{hT_0}{c_u} \tag{7}$$

$$R = T_0 D + D_L + z_a S\sqrt{T_0 + L} \tag{8}$$

c) Then calculated total cost of inventory O_T with the following equation:

$$(O_T)_0 = D \cdot p + \frac{A}{T_0} + h\left(R - D_L - \frac{T_0 D}{2}\right) + \frac{c_u}{T_0} N \tag{9}$$

d) Recalculate the value of T_0 using the following equation and then return to step (2)

$$T_n = T_0 + \Delta T_0 \tag{10}$$

e) If the value of $(O_T)_1$ less than $(O_T)_0$, then return to step (4). If the value of $(O_T)_1$ more than $(O_T)_0$, then return to step (4) with the reduction iteration

2.4. Forecasting

Forecasting is used to estimate how much demand will be in the future which includes needs in terms of quantity, quality, and time required in order to meet demand for goods (Makridakis, 2008). One of the forecasting methods is the time series method in which the analysis is carried out based on the forecast results which are compiled on the relationship pattern between the variables being sought and the time variable that influences them. The purpose of the time series is to find patterns in historical data series and extrapolate these patterns to the future (Li et al., 2023). The types of data patterns in time series are divided into four, which are horizontal, seasonal, cyclical, and trend.

2.5. Additive Decomposition

Additive Decomposition forecasting is a method used for data that contains trend and seasonal elements, where the seasonal elements indicate a relatively constant seasonal fluctuation. According to makridakis (2008). The equation used for forecasting with the Holt-Winter Exponential Additive method is as follows:

a) Calculating the moving average of the period whose length is is equal to the seasonal length (MA_t) and (CMA_t)

$$MA_t = \frac{1}{N}(X_1 + \cdots + X_{N-1} + X_N) \tag{11}$$

$$CMA_t = \frac{(MA_{t-1} + MA_t)}{2}. \tag{12}$$

b) Determine the seasonal value (I_t)

$$I_t + E_t = X_t - M_t. \tag{13}$$

In the calculation of the seasonal value we will remove the error with medial average and adjustment value, Medial average is averaging the values in each period minus the minimum and maximum values in that period. Adjustment value is medial average sum divided by sum of medial average.

c) Determine the trend value (T_t)

$$T_t = a - b_t. \tag{14}$$

with

$$a = \frac{\Sigma X_t \Sigma t^2 - \Sigma \mathrm{t}\, \Sigma X_t t}{n\Sigma t^2 - (\Sigma t)^2}$$

$$b = \frac{n\,\Sigma t\,X_t - \Sigma t\,\Sigma X_t}{n\,\Sigma t^2 - (\Sigma t)^2}$$

d) Determine the cycle (C_t)

$$C_t = M_t - T_t. \tag{15}$$

e) Determine the forecast value (F_t)

$$F_t = I_t + T_t + C_t \tag{16}$$

2.6. Validation of Forecasting Method Accuracy

In this research, the calculation of forecasting accuracy is used with the Mean Absolute Percentage Error (MAPE). MAPE is a measurement of accuracy by calculating the total percentage between forecasting data that deviates from the actual data (Baykal et al., 2022). The MAPE formula is as follows:

$$PE = \left(\frac{X_i - F_i}{X_i}\right)(100).$$

$$MAPE = \sum_{t=1}^{n} \frac{|PE_t|}{n}. \tag{17}$$

The MAPE criteria according to Baykal et al. (2022) can be seen in Table 2

Table 2: The MAPE criteria

MAPE	Interpretation
$< 10\%$	High forecasting accuracy
$10\% \leq \text{MAPE} < 20\%$	Good forecasting accuracy
$20\% \leq \text{MAPE} < 50\%$	Reasonable forecasting accuracy
≥ 50	Weak and inaccurate forecasting accuracy

3. Materials and Methods

3.1. Materials

The object of this research was conducted at Merry Optik which is a company engaged in the optical industry, a company engaged in the health sector that provides health services in the field of eyewear. The main product that is Merry Optik's mainstay is photochromic glasses. The company is located at Jalan Nanjung KM 4, Margaasih District, Bandung City. The data in this study are primary data, namely eyeglass sales data in the period January 2017 to December 2021. Microsoft Excel and SPSS are the software used.

3.2. Methods

The research method used in this research is descriptive quantitative method. The reason for using the quantitative method is because the research data used is in the form of numbers and being analyzed using a model then the results will be given a discussion. It is said to be descriptive because the results obtained will be described and explained regarding the object under the research through the data that has been collected. As for the research process, data collection methods are obtained as follows:

a) Observation
b) Interview
c) Literature Review
d) Documentary Review

4. Results and Discussion

The data shown are the graph of sales data patterns for glasses products in Figure 1.

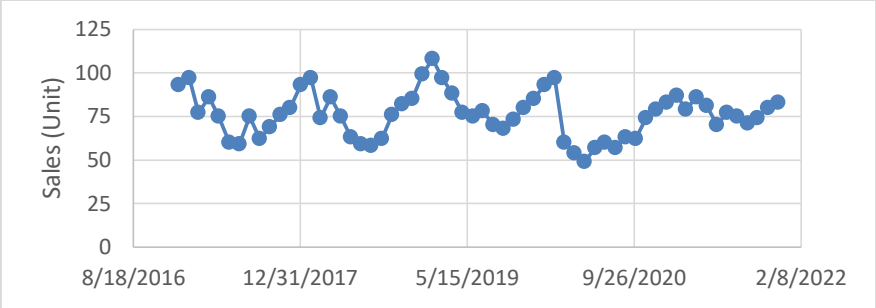

Figure 1: Product

The pattern of product sales data is not fixed but has elements of a decreasing trend and repeats over a certain period, so it can be assumed that the data pattern is seasonal. Checking the season elements is seen from the comparison of each individual's value with the average value of each season, where one period will be less than the season's average value and another period will be greater than the season's average value. Thus, the product has a seasonal length of 12 periods.

Because the data has elements of trend and seasonality, forecasting with the additive decomposition method is chosen. There are three main steps in forecasting using the Additive decomposition method, namely calculating the moving average value, determining the seasonal length, calculating the trend value and calculating the forecast value.

a) Calculating Moving Average
Calculations are calculated by using equations (11) and (12). The calculation results for the initialization value of product is presented in Tables 3.

Table 3: The value of moving average the period 7 to 54

Period (t)	Moving average (CMA_t)	Period (t)	Moving average (CMA_t)	Period (t)	Moving average (CMA_t)	Period (t)	Moving average (CMA_t)	Period (t)	Moving average (CMA_t)	Period (t)	Moving average (CMA_t)
7	75.750	15	74.333	23	79.417	31	82.917	39	69.208	47	71.000
8	75.750	16	74.625	24	80.000	32	82.208	40	68.542	48	72.875
9	75.625	17	75.167	25	81.292	33	80.208	41	67.833	49	74.125
10	75.500	18	75.625	26	82.583	34	77.250	42	67.333	50	75.583
11	75.500	19	76.083	27	83.333	35	74.667	43	66.667	51	76.667
12	75.625	20	76.792	28	83.458	36	72.750	44	65.833	52	77.500
13	75.750	21	78.208	29	83.250	37	71.250	45	66.208	53	78.250
14	75.042	22	79.250	30	83.167	38	69.958	46	68.333	54	78.667

b) Calculating Seasonal Value
Calculation is calculated by using equation (13). The result of calculating seasonal value without error are presented in Tables 4 and 5.

Table 4: The value of seasonal value with error the period 7 to 54

Period (t)	Seasonal + error $(I_t + E_t)$	Period (t)	Seasonal + error $(I_t + E_t)$	Period (t)	Seasonal + error $(I_t + E_t)$	Period (t)	Seasonal + error $(I_t + E_t)$
7	-16.750	19	-17.083	31	-4.917	43	-6.667
8	-0.750	20	-18.792	32	-12.208	44	-8.833
9	-13.625	21	-16.208	33	-12.208	45	-3.208
10	-6.500	22	-3.250	34	-4.250	46	-6.333
11	0.500	23	2.583	35	5.333	47	3.000
12	4.375	24	5.000	36	12.250	48	6.125
13	17.250	25	17.708	37	21.750	49	8.875
14	21.958	26	25.417	38	27.042	50	11.417
15	-0.333	27	13.667	39	-9.208	51	2.333
16	11.375	28	4.542	40	-14.542	52	8.500
17	-0.167	29	-6.250	41	-18.833	53	2.750
18	-12.625	30	-8.167	42	-10.333	54	-8.667

Table 5: The value of seasonal value the period 1 to 12

Period (t)	Season 1	Season 2	Season 3	Season 4	Medial average	Seasonal (I_t)
1	-16.75	-17.08	-4.92	-6.67	-11.71	-12.03
2	-0.75	-18.79	-12.21	-8.83	-10.52	-10.84
3	-13.63	-16.21	-12.21	-3.21	-12.92	-13.24
4	-6.50	-3.25	-4.25	-6.33	-5.29	-5.62
5	0.50	2.58	5.33	3.00	2.79	2.47
6	4.38	5.00	12.25	6.13	5.56	5.24
7	17.25	17.71	21.75	8.88	17.48	17.16
8	21.96	25.42	27.04	11.42	23.69	23.36
9	-0.33	13.67	-9.21	2.33	1.00	0.68
10	11.38	4.54	-14.54	8.50	6.52	6.20
11	-0.17	-6.25	-18.83	2.75	-3.21	-3.53
12	-12.63	-8.17	-10.33	-8.67	-9.50	-9.82

c) Calculating Trend Value
Calculation is calculated by using equation (14). The result of calculating trend value is presented in Tables 6.

Table 6: The value of trend value the period 1 to 60

Period (t)	Trend (T_t)	Period (t)	Trend (T_t)	Period (t)	Trend (T_t)	Period (t)	Trend (T_t)	Period (t)	Trend (T_t)
1	78.42	13	77.49	25	76.56	37	75.63	49	74.70
2	78.34	14	77.41	26	76.48	38	75.55	50	74.62
3	78.26	15	77.33	27	76.40	39	75.47	51	74.55
4	78.19	16	77.26	28	76.33	40	75.40	52	74.47
5	78.11	17	77.18	29	76.25	41	75.32	53	74.39
6	78.03	18	77.10	30	76.17	42	75.24	54	74.31
7	77.95	19	77.02	31	76.09	43	75.17	55	74.24
8	77.88	20	76.95	32	76.02	44	75.09	56	74.16
9	77.80	21	76.87	33	75.94	45	75.01	57	74.08
10	77.72	22	76.79	34	75.86	46	74.93	58	74.00
11	77.64	23	76.71	35	75.78	47	74.86	59	73.93
12	77.57	24	76.64	36	75.71	48	74.78	60	73.85

d) Calculating Cycle Value
Calculation is calculated by using equation (15). The result of calculating cycle value is presented in Tables 7.

Table 7: The value of cycle the period 7 to 54

Period (t)	Cycle (C_t)	Period (t)	Cycle (C_t)	Period (t)	Cycle (C_t)	Period (t)	Cycle (C_t)	Period (t)	Cycle (C_t)	Period (t)	Cycle (C_t)
7	-2.204	15	-3.001	23	2.702	31	6.822	39	-6.267	47	-3.855
8	-2.126	16	-2.632	24	3.363	32	6.191	40	-6.856	48	-1.903
9	-2.174	17	-2.012	25	4.732	33	4.269	41	-7.487	49	-0.575
10	-2.221	18	-1.477	26	6.101	34	1.388	42	-7.909	50	0.961
11	-2.144	19	-0.941	27	6.929	35	-1.118	43	-8.498	51	2.121
12	-1.941	20	-0.155	28	7.131	36	-2.957	44	-9.254	52	3.032
13	-1.739	21	1.339	29	7.000	37	-4.380	45	-8.802	53	3.860
14	-2.370	22	2.458	30	6.995	38	-5.594	46	-6.599	54	4.354

e) Calculating Forecasting Value
Calculations are performed using equation (16). The result of calculating the sales forecasting value of product are presented in Table 8.

Table 8: The value of cycle the period 7 to 54

Period (t)	Forecasting (F_t)	Period (t)	Forecasting (F_t)
61	90.92579	67	61.27349
62	97.05666	68	62.38353
63	74.29169	69	59.91023
64	79.73506	70	67.45776
65	69.92842	71	75.46363
66	63.55929	72	78.157

Based on calculations through equation (17), the results show that the MAPE value is less than 20%. where the MAPE value is 6.373%.

After knowing the results of product forecasting, then a normality test will be carried out on product sales data. The normality test uses the Kolmogorov-Smirnov test with the test hypothesis:

H_0 : *The observed frequency distribution is normal*

H_1 : *The observed frequency distribution is not normal*

with the following test criteria:

a. If the significant value > 0.05 then H_0 accepted
b. If the significant value < 0.05 then H_0 rejected

Calculations are calculated with SPSS software to carry out the Kolmogorov-Smirnov Test process.

One-Sample Kolmogorov-Smirnov Test

			Penjualan
N			72
Normal Parameters[a,b]	Mean		75.75
	Std. Deviation		12.730
Most Extreme Differences	Absolute		.092
	Positive		.092
	Negative		-.070
Test Statistic			.092
Asymp. Sig. (2-tailed)[c]			.200[d]
Monte Carlo Sig. (2-tailed)[e]	Sig.		.139
	99% Confidence Interval	Lower Bound	.130
		Upper Bound	.148

a. Test distribution is Normal.
b. Calculated from data.
c. Lilliefors Significance Correction.
d. This is a lower bound of the true significance.
e. Lilliefors' method based on 10000 Monte Carlo samples with starting seed 2000000.

Figure 2: Kolmogorov-Smirnov test result

Based on Figure 4, the significance value is greater than 0.05. This indicates that the hypothesis is accepted and the data is normally distributed. Because the data is normally distributed, the data can be used in inventory control calculations using the Model P probabilistic inventory method with back order conditions.

The data needed for the probabilistic inventory method calculation process Q Model with lost sales conditions can be seen in Table 16. Calculations are performed using equations (6), (7), (8), (9), and (10). The inventory control calculation results for each product are presented in Table 9 and 10.

Table 9: P Model probabilistic inventory method calculation data with back order condition

Product	Glasses
Number of Requests per Week (D)	880
Purchase Cost (p)	IDR 500,000
Order Cost (A)	IDR 200,000
Holding Cost (h)	IDR 60,000
Shortage Cost (c_u)	IDR 250,000
Lead Time (L)	0.0027
Standard Deviation (S)	11.790

Table 10: Hadley-Within calculation results for product inventory

Iteration (T_n)	Max Inventory (R)	Quantity of goods shortage (N)	Safety stock (ss)	Service level (η)	Total cost of inventory (O_T)
$T_0\,(+)$	86	0.118	7.240	95%	IDR 445,371,229
$T_1(+)$	90	0.1338	7.232	94.35%	IDR 445,401,138
$T_1(-)$	82	0.115	7.062	95.12%	IDR 445,375,751

5. Conclusion

The results showed that the Additive Decomposition forecasting method is a good method used to forecast the demand for glasses at Merry Optik because the forecasting calculation produces a MAPE value of less than 20%. By using the P model based on sales forecast data, companies can save on total inventory costs by 9.77% and cut the period between orders to 32 days with a service level of 94.35%. The additive decomposition method can be used to determine forecasting sales data.

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