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Analysis of forecasting and inventory control of raw material supplies in PT INDAC INT'L

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Abstract. This study discusses the data forecasting sales of carbon electrodes at PT. INDAC INT L uses winters and double moving average methods, while for predicting the amount of inventory and cost required in ordering raw material of carbon electrode next period using Economic Order Quantity (EOQ) model. The result of error analysis shows that winters method for next period gives result of MAE, MSE, and MAPE, the winters method is a better forecasting method for forecasting sales of carbon electrode products. So that PT. INDAC INT L is advised to provide products that will be sold following the sales amount by the winters method.

1. Introduction

This study discusses the data forecasting sales of carbon electrodes at PT. INDAC INT L uses winters and double moving average methods, while for predicting the amount of inventory and cost required in ordering raw material of carbon electrode next period using Economic Order Quantity (EOQ) model. The result of error analysis shows that winters method for next period gives result of MAE, MSE, and MAPE, the winters method is a better forecasting method for forecasting sales of carbon electrode products. So that PT. INDAC INT L is advised to provide products that will be sold following the sales amount by the winters method.

The rapid development of science and technology increasingly sophisticated push the rate of economic growth. So the competition between companies is getting tighter, therefore every company should estimate the estimated amount of sales and establish the control of raw material inventory effectively and efficiently, so that the company can achieve the desired goals. Raw materials are an initial process of production transformation which will then be processed into finished products [2]. Every company should have a goal to make a profit, but to gain profit is not easy, because it is influenced by several factors to be overcome. One of the factors that influence it is the production problem. If the production process smoothly then the company will be able to achieve its objectives, but if the production process is not smooth, then the purpose of the company will not be achieved. Usually one of the factors causing the failure of production is due to the absence of raw materials that can be processed in the production process.

Errors in the determination of raw material purchases will also affect the profits of the company. Purchase of raw materials that are too large will affect the amount of storage costs, which include maintenance costs, warehouse rental costs and costs incurred in connection with material damage. But

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if the purchase of raw materials are too low, will affect the profits of the company, because there will be a stock out which resulted in a company failed production.

Previous research related to this issue was carried out by Womack et al in 1990 on the principle of lean production to solve inventory problems that consume too much physical space, create financial burdens, and increase the likelihood of damage to the goods. Wacker et al in 1996 on inventory management and control. Tatoglu and Zaim in 2007 on the concepts and techniques of inventory implementation in the business world and its impact on company performance. In 2008 Koumanakos in the management of inventory system with EOQ, MRP and ERP method, while in 2012 Pamungkas and Sutanto test analysis of raw material control, the method used is the method of forecasting is a trend projection method where this technique adjusts with the trend line series The historical data point of a company which is then projected with forecasts for the coming period, and the EOQ method for determining the optimal number of orders or purchases. Lwiki et al in 2013 examines the impact of inventory management on financial performance. In 2014 Katiandagho et al studied the wood supply control system for the furniture industry, the method used was the EOQ method to analyze the optimal volume of wood raw materials required for production, as well as calculate the total cost of inventory to be incurred by the company.

2. Forecasting

Forecasting is an attempt to predict future circumstances through testing of the past. The essence of forecasting is the approximate future events on the basis of patterns in the past, and the use of policies against projections with patterns in the past [7]. The Time Series method is a quantitative method used to analyze data sets that are a function of time. This method assumes that some pattern or combination of patterns always repeats over time, and the archetype can be identified on the basis of historical data of the time series.

1. According [3] pattern of a series of data in time series can be grouped into 4 kinds namely: 1. Horizontal (constant), i.e. when the data fluctuates around the average stably. The pattern is a straight horizontal line.
2. Trend, that if the data has a tendency, either the direction increases or decreases over time.
3. Seasonal (seasonal) is when the pattern is a repetitive movement regularly in any given period.
4. Cyclical i.e. when data is influenced by long-term economic fluctuations, such as business life cycle.

2.1 Triple Exponential Smoothing Winters

The Winters method is based on three smoothing equations, one for stationary elements, one for trends, and one for seasonality. The basic equations for the winters method are as follows:

Over all smoothing $$\boldsymbol{S_t = \alpha \frac{X_t}{I_{t-L}} + (1-\alpha)(S_{t-1} + b_{t-1})} \quad (1)$$

Trend slicing $$b_t = \gamma(S_t - S_{t-1}) + (1-\gamma)b_{t-1} \quad (2)$$

Seasonal Smoothing $$I_t = \beta \frac{X_t}{S_t} + (1-\beta)I_{t-L} \quad (3)$$

Forecast $$F_{t+m} = (S_t + b_t m)I_{t-L+m} \quad (4)$$

with :

X_t = actual data at time t
S_t = smoothing factor at time t
L = seasional length
b = trend smoothinh factor
I = seasional adjustment factor
F_{t+m} = predicted value for m next periode

Initialization

Preliminary estimate S_{L+1}, b_{L+1}, I_L can be obtained as follows :

1. Initial smoothing using :
$$S_{L+1} = X_{L+1} \quad (5)$$
2. Estimate trend using :
$$b_{L+1} = \frac{1}{L}\left[\frac{X_{L+1}-X_1}{L} + \frac{X_{L+2}-X_2}{L} + \cdots + \frac{X_{L+L}-X_L}{L}\right] \quad (6)$$
3. Seasional factor use :
$$I_L = \frac{X_L}{\bar{X}} \quad (7)$$
Where :
$$\bar{X} = \frac{1}{L}\sum_{i=1}^{L} X_i \quad (8)$$

The Winters method is based on three smoothing equations, one for stationary elements, one for trends, and one for seasonality. Forecasting with this method is based on the serial data projection that is passed by moving average. The estimated value for a period is the average of the last observed N value [4].

2.2 Double Moving Average

According to [3] forecasting with this method is based on the serial data projection that is passed by the moving average. The estimated value for a period is the average of the last observed N value . There are several steps used to determine the forecast by double moving averages method, which is as follows:

1. Calculate the first moving average (S_t') , obtained from existing historical data so that it can be written as follows:
$$S_t' = \frac{X_t + X_{t-1} + X_{t-2} + \cdots + X_{t-N+1}}{N}. \quad (9)$$
2. Calculate the second moving average (S_t'') , obtained from the first moving average so that it can be written as follows:
$$S_t'' = \frac{S_t' + S_{t-1}' + S_{t-2}' + \cdots + S_{t-N+1}'}{N} \quad (10)$$
3. Determine the a_t constant value:
$$a_t = S_t' + (S_t' - S_t'') \quad (11)$$
4. Determine slope value b_t :
$$b_t = \frac{2}{N-1}(S_t' - S_t'') \quad (12)$$
5. Determine the forecast value F_{t+m} :
$$F_{t+m} = a_t + b_t m \quad (13)$$

with m is the period ahead of time t.

2.3 Standard Statistics Size

X_t is the actual data for period t and F_t is the forecast for the same period then the error value can be defined as:
$$e_t = X_t - F_t \quad (14)$$

If there is actual data and forecasting for time period n, then there are a number of n errors and standard statistical measures can be defined as follows:

1. Mean Absolute Error (MAE)
$$MAE = \frac{1}{n}\sum_{t=1}^{n} |e_t| \quad (15)$$
2. *Mean Squared Error (MSE)*

$$MSE = \frac{1}{n}\sum_{t=1}^{n} {e_t}^2 \quad (16)$$

3. *Percentage Error (PE_t)*

$$PE_t = \frac{X_t - F_t}{X_t} \cdot 100\% \quad (17)$$

4. *Mean Absolute Percentage Error (MAPE)*

$$MAPE = \frac{1}{n}\sum_{t=1}^{n} |PE_t| \quad (18)$$

with :

e_t = error value
X_t = actual data at time t
n = number of time periods
F_t = forecast value in perio t

3. Inventory

According to [1] inventory is an asset that includes goods owned by the company for the purpose of sale in a normal period of business. So the inventory is the number of goods provided to meet the demand from customers.

According to [5] EOQ is the most economical volume or amount of purchases to run on every purchase. To meet that need, it can be calculated to meet the most economical needs of a number of items that will be obtained by purchase using a minimal cost. The raw materials available in ensuring the smoothness of the production process and the costs incurred by the company with respect to the company to a minimum, then the action that needs to be done is to determine the amount of raw material inventory, the number of buffer stock and reorder point.

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The raw materials available in ensuring the smoothness of the production process and the costs incurred by the company in relation to the company to a minimum, then the action that needs to be done is to determine the amount of raw material inventory, the amount of buffer stock and reorder point. Terms of data using the EOQ method are:

a. demand level is known and is constant (deterministic)
b. lead times are known and are constant
c. the ordered goods are assumed to be available soon or the production rate of goods ordered abundantly
d. every order is received in one shipment and can be used immediately
e. there is no back order because it is out of stock
f. purchase price or manufacturing cost is unchanged
g. no discounts (quantity discount)
h. Large carrying costs depend on a straight line with the average inventory amount.
i. The amount of ordering cost or set up cost ordered is fixed and does not depend on the number of items in each lot.
j. Items are a one-of-a-kind product and have no relationship with other products.

3.1 *EOQ Model with More Capacity*

If the production capacity is denoted by *P* and the demand is denoted by *D*, where *P* > *D*, then in every production cycle there will always be an over-production of (*P* - *D*) units. The main features in the EOQ model with more capacity are:

a. Excess stock due to market demand is smaller than production capacity.
b. Stock will incur more storage costs continuously during the production process takes place.

Total Optimum Cost of EOQ Model More Capacity

$$TC = \frac{1}{2}.\left(\frac{Q_0}{P}\right).(P-D).C_c + \left(\frac{D}{Q_0}\right).C_s \quad (19)$$

$$\frac{dTC}{dQ_0} = \frac{P-D}{2P}\cdot C_c - \frac{D}{{Q_0}^2}\cdot C_s = 0$$

$$\frac{P-D}{2P}\cdot C_c = \frac{D}{{Q_0}^2}\cdot C_s$$

$${Q_0}^2 = \frac{2\cdot P\cdot D\cdot C_s}{(P-D)\cdot C_c}$$

$$Q_0 = \sqrt{\frac{2.P.D.C_s}{(P-D).C_c}} \quad (20)$$

4. Result And Discussion

Data taken from PT. INDAC INT L includes sales data of carbon electrodes from 2014 to 2016 seen in Table 1.

Table 1. Sales Data of Carbon Electrode PT. INDAC INT L
Period January 2014 - December 2016

2014		2015		2016	
Month	Sales	Month	Sales	Month	Sales
Jan	382.414	Jan	374.994	Jan	336.254
Feb	344.456	Feb	355.069	Feb	400.880
Mar	218.447	Mar	378.202	Mar	350.878
Apr	403.949	Apr	521.911	Apr	469.887
May	387.080	May	511.122	May	458.165
Jun	525.646	Jun	454.074	Jun	604.351
Jul	270.406	Jul	334.385	Jul	234.281
Aug	439.912	Aug	477.189	Aug	369.692
Sep	505.750	Sep	515.231	Sep	405.017
Oct	390.415	Oct	454.074	Oct	416.751
Nov	463.436	Nov	466.970	Nov	364.620
Dec	435.005	Dec	342.842	Dec	387.380

The first step of data processing is to analyze the shape of the data pattern through the data pattern graph by plot the data in Table 1, making it easier in determining the method of forecasting that will be used. The plot of data the number of sales of carbon electrodes at PT. INDAC INT L can be seen in Figure 1.

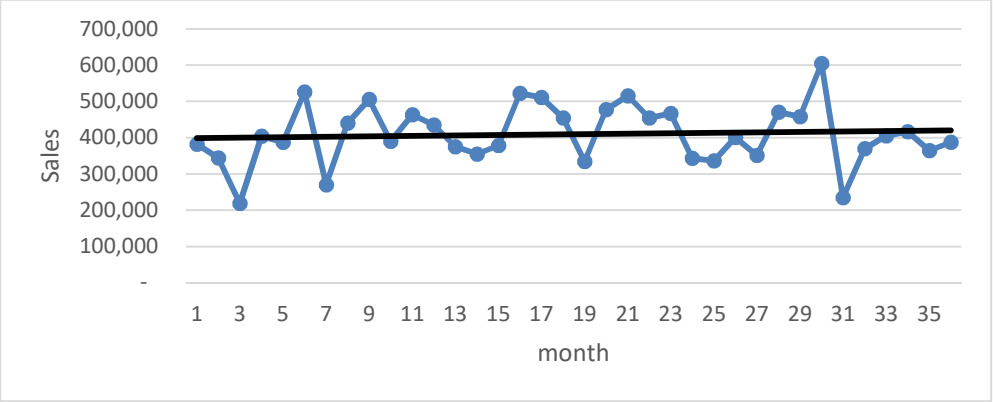


Figure 1. Plot Data Total Sales of Carbon Electrodes at PT. INDAC INT L

Seasonal factors are identified in data on the number of sales of carbon electrodes at PT. INDAC INT L. In Figure 1 it is shown that the pattern of changes is repeated automatically from year to year. In January to December the data increases and decreases annually. This indicates that the data on the number of sales of carbon electrodes is data that has a trend and seasonal patterns with seasonal variations that fluctuate.

4.1 *Forecasting Using Winters Method*

The Winters method is based on three equations, one for stationers, one for trend and one for seasonality. In predicting the data using the Winters method it is necessary to determine the optimal α, β, and agar in order to obtain the forecast result which has the smallest error. From Table 1, data processing is performed to determine the MAE (Mean Absolute Error), MSE (Mean Squared Error) and MAPE (Mean Absolute Percentage Error) with the smallest value according to the calculation in, to obtain the values α, β, and γ in Table 2 as follows.

Table 2. Determination Process α, β, and γ in Winters Method

Alpha	Beta	Gamma	MAE	MSE	MAPE
0,65	0,1	0,1	53881,39	7250589173,63	13,1844
0,7	0,1	0,1	53850,01	7243649546,78	13,1505
0,75	0,1	0,1	54067,13	7288454335,98	13,1910
0,7	0,55	0,1	51803,83	6954395820,63	12,9208
0,7	0,6	0,1	51751,46	6943710012,76	12,9271
0,7	0,65	0,1	51801,39	6937339821,57	12,9511
0,7	0,6	0,1	51751,46	6943710012,76	12,9271
0,7	0,6	0,15	51299,98	6944105781,19	12,8048
0,7	0,6	0,2	51475,99	7039913176,73	12,8779

Based on Table 2 it can be seen that the most α, β, and nilai values are α = 0.7, β = 0.6 and γ = 0.15. Furthermore, the calculation process using winters method, which is assumed $S_{13} = X_{13}$ based on equation (1) obtained value S_{13} = 374.994. Next will be calculated value b_{13} based on the equation (2) obtained. After the initialization process is complete, then the calculation of single, seasonal and seasonal smoothing for the period from January 2014 to December 2016, with α = 0,7, β = 0,6, and γ = 0,15 (parameter obtained by trial method and error).

Furthermore, for the forecast of sales of carbon electrodes in the next year is obtained in Table 3.

Table 3. Data Processing Using Winters Method($\alpha = 0.7$, $\beta = 0.6$, and $\gamma = 0.15$)

Period (t)	Actual Value	Single exp smoothing	seasional smoothing	Trend smoothing	Forecast	$\lvert e_t \rvert$
1	382414		0,96			
2	344456		0,87			
3	218447		0,55			
4	403949		1,02			
5	387080		0,97			
6	525646		1,32			
7	270406		0,68			
8	439912		1,11			
9	505750		1,27			
10	390415		0,98			
11	463436		1,17			
12	435005		1,10			
13	374994	374994	0,99	34929		
14	355069	409614	0,87	34883	355451	382,4
15	378202	614777	0,59	60425	244432	133769,8
16	521911	561834	0,96	43419	686600	164688,8
17	511122	548755	0,95	34945	589769	78646,5
18	454074	415318	1,19	9688	772372	318297,6
19	334385	471364	0,70	16641	289305	45080,7
20	477189	448034	1,08	10646	540424	63234,9
21	515231	420887	1,24	4977	583968	68737,0
22	454074	451170	1,00	8773	418544	35530,2
23	466970	418174	1,14	2507	536583	69612,7
24	342842	345360	1,03	-8791	460671	117829,4
25	336254	339917	0,99	-8289	331544	4710,2
26	400880	423171	0,92	5443	287505	113375,6
27	350878	545534	0,62	22981	252485	98393,1
28	469887	511717	0,94	14461	548116	78228,6
29	458165	495940	0,93	9925	499143	40977,5
30	604351	508675	1,19	10347	599594	4756,9
31	234281	390685	0,64	-8904	362237	127955,7
32	369692	353705	1,06	-13115	413091	43399,3
33	405017	330125	1,23	-14685	423609	18592,5
34	416751	387240	1,04	-3915	314490	102261,3
35	364620	339543	1,10	-10482	435712	71092,6
36	387380	361057	1,06	-5683	340134	47245,8
37					350954	
38					320029	
39					213815	
40					316876	
41					310604	

Period (t)	Actual Value	Single exp smoothing	seasional smoothing	Trend smoothing	Forecast	$\|e_t\|$
42					388090	
43					205286	
44					334505	
45					382311	
46					317773	
47					328095	
48					309615	

Data forecast of the sales of carbon electrodes at PT. INDAC INT L uses the Winters method with $\alpha = 0.7$, $\beta = 0.6$ and $\gamma = 0.15$ can be seen in Figure 2.

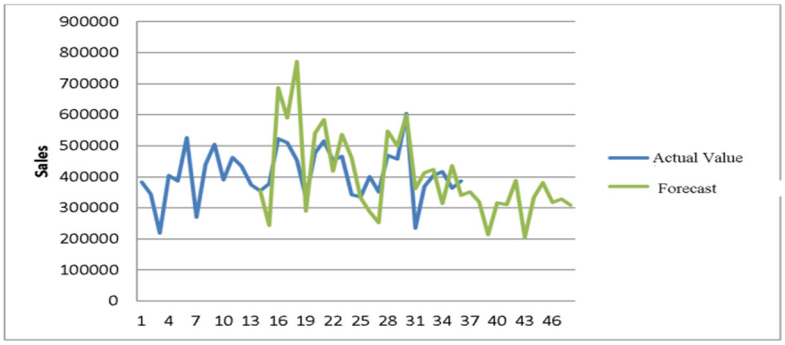


Figure 2. Plot Comparison of Actual Data with Sales Forecast Data with Winters Method

In predicting the data using the double moving average method, it is necessary to determine the optimal number of N periods to obtain the forecast result which has the smallest error. The statistical measures used to determine the optimal N period are MAE (Mean Absolute Error), MSE (Mean Squared Error) and MAPE (Mean Absolute Percentage Error), the process of selecting the N period can be seen in Table 4.

Table 4. Selection Process Period *N* on Double Moving Average Method

Comparison MAE, MSE, MAPE			
MA(NxN)	MAE	MSE	MAPE
2x2	117530,7	22821305711	31,20734
3x3	102046,5	18668955972	27,5938
4x4	84464,04	12432935095	22,47225
5x5	75811,95	10852098796	20,20566
6x6	74878,28	9422501714	19,3164
7x7	73941,68	8671545666	18,96529
8x8	68671,93	8539855893	17,84794
9x9	68247,29	8335163182	18,46958
10x10	70346,97	8331330579	19,03834
11x11	68946,46	9068398796	19,33037
12x12	72237,58	9188822106	20,43182

Based on Table 4, from the minimum MAE, MSE and MAPE values, the period N = 9 is used. The results of the calculation process can be seen in Table 5.

Table 5. Data Processing Using Double Moving Average Method (N = 9)

Period (t)	Actual Value	S'_t	S''_t	a_t	b_t	Forecast	$\|e_t\|$
1	382414						
2	344456						
3	218447						
4	403949						
5	387080						
6	525646						
7	270406						
8	439912						
9	505750	386451,2					
10	390415	387340,3					
11	463436	400560,2					
12	435005	424622,2					
13	374994	421405,0					
14	355069	417848,1					
15	378202	401465,5					
16	521911	429410,5					
17	511122	437322,7	411825,1	462820,3	6374,4		
18	454074	431580,9	416839,5	446322,4	3685,4	469195	15120,6
19	334385	425355,4	421063,4	429647,4	1073,0	450008	115622,4
20	477189	426883,5	423988,2	429778,9	723,8	430720	46468,5
21	515231	435797,5	425229,9	446365,1	2641,9	430503	84728,7
22	454074	444584,2	427805,4	461363,1	4194,7	449007	5067,1
23	466970	457017,7	432157,5	481877,9	6215,0	465558	1412,4
24	342842	453088,8	437893,5	468284,2	3798,8	488093	145251,1
25	336254	432460,2	438232,3	426688,1	-1443,0	472083	135829,0
26	400880	420211,1	436331,1	404091,2	-4030,0	425245	24364,8
27	350878	408744,9	433793,7	383696,1	-6262,2	400061	49183,1
28	469887	423800,6	433621,0	413980,3	-2455,1	377434	92453,2
29	458165	421686,9	433043,6	410330,3	-2839,2	411525	46640,3
30	604351	431589,1	432576,0	430602,3	-246,7	407491	196859,9
31	234281	407167,7	428418,6	385916,8	-5312,7	430356	196074,2
32	369692	396359,0	421678,7	371039,2	-6329,9	380604	10912,4
33	405017	403267,3	416143,0	390391,6	-3218,9	364709	40307,4
34	416751	412211,4	413893,1	410529,8	-420,4	387173	29578,6
35	364620	408182,5	412556,6	403808,4	-1093,5	410109	45489,8
36	387380	412238,2	412944,8	411531,7	-176,6	402715	15335,2

Period (t)	Actual Value	S'_t	S''_t	a_t	b_t	Forecast	$\|e_t\|$
37						411355	
38						411178	
39						411002	
40						410825	
41						410649	
42						410472	
43						410295	
44						410119	
45						409942	
46						409765	
47						409589	
48						409412	

Plot data forecast of the sales of carbon electrodes at PT. INDAC INT L by using the method of double moving average for period N = 9 can be seen in Figure 3

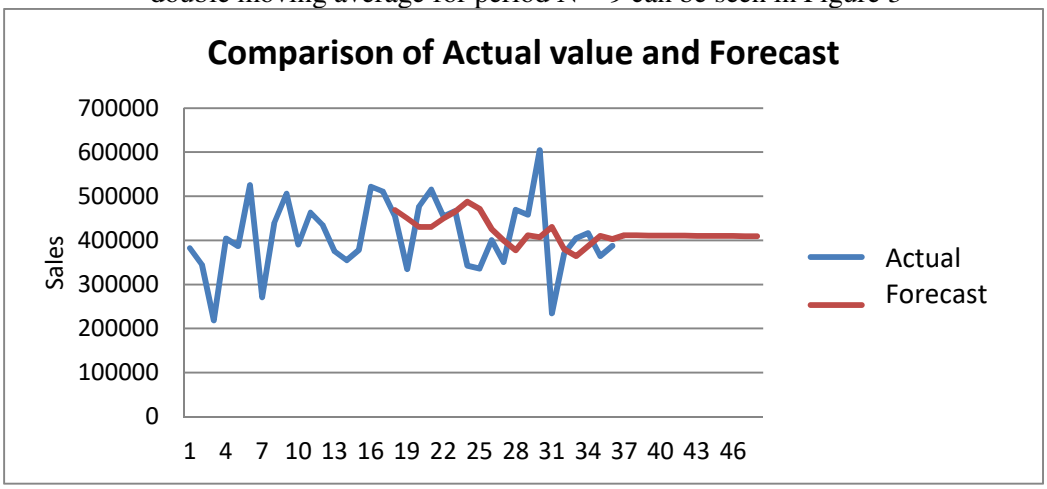


Figure 3. Plot Comparison of Actual Data with Sales Forecasting Data Using Double Moving Average Method For Period N = 9

From the sales prediction value obtained by using the winters and double moving average methods, the real data comparison with the forecast results is as follows.

Table 6. Comparison of Sales Data and Forecast Results

Actual Data 2016		Forecast with *Winters method* 2017		Forecast with *Double Moving Average* 2017	
Month	Sales	Month	Sales	Month	Sales
Jan-16	336.254	Jan-17	350.954	Jan-17	411.355
Feb-16	400.880	Feb-17	320.029	Feb-17	411.178
Mar-16	350.878	Mar-17	213.815	Mar-17	411.002
Apr-16	469.887	Apr-17	316.876	Apr-17	410.825
May-16	458.165	May-17	310.604	May-17	410.649
Jun-16	604.351	Jun-17	388.090	Jun-17	410.472
Jul-16	234.281	Jul-17	205.286	Jul-17	410.295
Aug-16	369.692	Aug-17	334.505	Aug-17	410.119
Sep-16	405.017	Sep-17	382.311	Sep-17	409.942
Oct-16	416.751	Oct-17	317.773	Oct-17	409.765
Nov-16	364.620	Nov-17	328.095	Nov-17	409.589
Dec-16	387.380	Dec-17	309.615	Dec-17	409.412

From Table 6 it can be seen that by using the method of double moving average get higher sales forecast value than Winters method. However, by using the double moving average method, sales will continue to decrease over each period due to negative b_t value. Unlike the winters method, the number of sales will continue to increase and decrease with the increasing number of sales smooth.
In addition, to determine the correct forecasting method, an error analysis of MAE, MSE and MAPE can be calculated. The calculation results can be seen in Table 7.

Table 7. Comparison of Error Analysis Winters Method and Double Moving Average Method

No.	Error Analysis	*Winters*	*Double Moving Average*
1	MAE	51299,9775	68247,2914
2	MSE	6944105781	8335163182
3	MAPE	12,8048356	18,46958009

In Table 7 can be seen comparison of error analysis results between winters and double moving average method. Based on the comparison of error analysis results winters method has a smaller error value than the method of double moving average. So that from Table 6 and Table 7 is directly proportional, which shows that the winters method is a better method to maximize sales at PT. INDAC INT L.

Implementation of EOQ method more capacity on inventory data obtained from PT. INDAC INT L is known as follows.

D = average number of carbon electrode demand in one year 3,777,953

P = average production capacity of 5,000,000 carbon electrodes in one year

C_c = carbon storage electrode cost Rp 1200 per unit
C_s = carbon electrode order cost Rp 150181,4 per unit

Based on the amount of known inventory data, it can be obtained the optimal order quantity as follows:

$$Q_0 = \sqrt{\frac{2 \cdot P \cdot D \cdot C_s}{(P-D) \cdot C_c}}$$

$$= \sqrt{\frac{2 \cdot 5.000.000 \cdot 3.777.953 \cdot 150181,4}{(5.000.000 - 3.777.953) \cdot 100}}$$

$$= 215.472 \text{ unit per period}$$

$$TC = \frac{1}{2} \cdot \left(\frac{Q_0}{P}\right) \cdot (P - D) \cdot C_c + \left(\frac{D}{Q_0}\right) \cdot C_s$$

$$= \frac{1}{2} \cdot \left(\frac{150.181}{5.000.000}\right) \cdot (5.000.000 - 3.777.953) \cdot 100 + \left(\frac{3.777.953}{150.181}\right) \cdot 150181,4$$

$$= 63.196.285 \text{ per period}$$

From the calculation results obtained, in order not to accumulate the production results, because the supply is greater than the demand, then PT. INDAC INT L is advised to purchase raw materials of 215,472 kg per period, with total expenses of Rp 63,196,285.00

5. Conclusion

Based on the results of data processing in the previous chapter, it can be drawn conclusion as follows:

Comparison of data patterns of sales amount of carbon electrodes at PT. INDAC INT L from January 2014 to December 2016 with the results of the next forecast, using the Winters method will provide better results for the company.

From the calculation results obtained, in order not to accumulate the production, because the inventory is greater than the demand, then PT. INDAC INT L is advised to purchase raw materials of 215,472 kg per period, with total expenses of Rp 63.196.28

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