Analysis of Commodity Inventory with Exponential Smoothing and Silver Meal Algorithm (Case Study)

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Abstract - Perum Bulog is one of State Owned Enterprises (SOE) Indonesia, which was built with the purpose of organizing the logistics business with food quality and adequate for fulfilling lives of many people. Therefore, Perum Bulog must be able to manage the supply of main food commodities. However, there are some obstacles infrequently occur that cause inventory management becomes impaired. Weather and natural disasters become factors of considerable influenced. These factors forced Bulog to find ways/methods that capable of maintaining the stability of the stock and minimize the possibility of additional operating expenses. The purpose of this study is to investigate the calculation of stock value in the particular of safety stock, reorder point, and lot sizing with exponential smoothing forecasting methods and Silver Meal algorithm, then determine the best method in accordance with Perum Bulog conditions.

Keyword: *Commodities, Inventory, Exponential Smoothing, Silver Meal.*

I. INTRODUCTION

Perum Bulog is one of Government Company established in 2003. One of Perum Bulog programs, which now still ongoing, is Raskin Program. This program started since food crisis in 1998, intended to supply the food needs, i.e. rice for poor society dan food crisis in Indonesia. The increasing of rice price is caused by some factors, for instance natural disaster or weather. These factors could appear spontaneously and emergency case. Therefore, the rice commodity supplies in Bulog must be rescheduled. The rescheduling will take time and the market automatically response with price increases.

The data which got from Ministry of Agriculture Republic of Indonesia (Kementan RI) on Ref.[1], the trend of rice price inside and outside the country in 2004-2012 is increased significantly. This can be seen in fig 1. Perum Bulog must have assets with over of 40 % of capital investment. Thus, the company should try to balance between inventory investment, customer service level, and cost efficiency that are major factors [1]. In order to achieve that balance, a good plan is needed to get better inventory control. This is company responsibility to decide a suitable strategic be used to guarantee optimal inventory control.

Figure 1 shows the growth rice price more dominant each year. When the global crisis occurred in 2007 and 2008, the average of domestic rice price grows to 5.29-7.38%, meanwhile, the international parity rice price fluctuated (Thai broke 5%) until 85.37%. In general, the average of domestic

rice price tend to increase in years; moreover, it is more than international rice price. To avoid the unstable rice price which tends to increase in years, Indonesia deposits rice in stocks. According to Perum Bulog interview, that to control the rice stocks, Perum Bulog always to keep Minimum Stock Requirements (MSR), ie availability of minimum stock to fulfill distribution needs. If MSR could not provide the needs, so that it will trigger the additional operational cost. In this situation, the new strategic must be considered to have better stocks control.

Fig. 1. The Growth Rice Price Domestic and International (2004-2012) [1]

II. LITERATURE REVIEW

Research of commodity inventory using silver meal algorithms is carried out by using lot sizing technique on three raw data orders as inputs. The result of this research states that company is having cost reduction of Rp 310,844,572.8 or equal to 12.09% by using lot sizing Silver Meal Algorithms techniques [3].

Lot Sizing techniques can be applied to replace the MSR technique previously applied by the company. The use of Lot Sizing technique is very appropriate to be used in determining the order quantity of inventory in which besides minimize the number of bookings, it can also minimize direct inventory costs and inverse cost of the inventory order [4].

Mainly, the value of the inventory should be recorded, classified, and then details are made on each in a period. In order to fulfill significant inventory values, the accurate information is needed so that a company will get advanced on business strategy planning. In this case, the use of information technology can be done to control the company well [5].

Inventory is an asset which includes goods belonging to the company intended to be sold within a specific business period

or stock of goods which are still under construction or production process, or the supply of raw materials inventory waiting in a production process. Inventories can be raw materials, auxiliary materials, and goods in process, completed goods, or parts [6]. Others reference state that inventories are materials, parts supplied and materials in the company's production process, and finished goods or products supplied to meet demand from consumers or customers every time [5]. From above opinions, they can be summarized that the inventory is a number of items or materials that are stored by the company to be processed or sold directly whenever the request occurred.

Previous research that covered the inventory investigations included development of inventory reduction process in automotive industry. This research also conducted an assessment of the inventory holding and create a process to manage the commodity groups and analyze it [7]. Other research explained for designing logistic distribution network with consider potential locations for shipments to reduce cost and service. This research is proposed a mathematical model to solve complex facility location problems and combine with genetic algorithm [8].

III. EXPONENTIAL SMOOTHING

Forecasting is a science to predict future events. This can be done by involving the retrieval of historical data and projection it in future to the mathematical model form [6].

A. Single Exponential Linear One Parameter

This method is used to set a certain weight on the available data and based on that weight it will know also the weights of the results of the previous forecast. The important point is that the assumption of past events will continue in the future. Therefore, it is necessary to determine the forecasted error which can be tolerated. If the forecasts are outside the range means that the value of α need to be adjusted, when the difference between the forecast results and the observed data is greater than a predetermined error [9].

The equation for single exponential linear parameters is as follows:

$$F_{t+1} = \alpha Y_t + (1 - \alpha)F_t. \quad (1)$$

Where:

F_t = forecast on the time of t

α = factor/smoothing constant (weighting)
($0 \leq \alpha \leq 1$)

Y_t = actual data on the time of t

While the technique of double exponential Brown linear one parameter is used for time series data that has a component that is a linear trend. In this technique, if the parameter (α) is not close to zero, the effect of the initial process is rapidly becoming less significant as time passes. If the parameter approaches zero, the initial process can play an important role for some period. This technique can be used to model the time series trend and requires less data as there is only one parameter is used [9].

The equation used in the implementation of a linear exponential smoothing parameter of Brown is as follows.

Single Smoothing:

$$F_{t+1} = \alpha Y_t + (1 - \alpha)F_t. \quad (2)$$

If $F_{t+1} = S'_t$, then

$$S'_t = \alpha Y_t + (1 - \alpha)S'_{t-1}. \quad (3)$$

$$\text{Double Smoothing: } S''_t = \alpha S'_t + (1 - \alpha)S''_{t-1}. \quad (4)$$

$$\text{Smoothing Trend: } a_t = S'_t + (S'_t - S''_t) = 2S'_t - S''_t.$$

$$b_t = \frac{\alpha}{(1-\alpha)}(S'_t - S''_t).$$

$$\text{Forecast: } F_{t+m} = a_t + b_t(m). \quad (5)$$

where:

F_t = Forecast on the time of $t + 1$

α = smoothing constant (weighting) ($0 \leq \alpha \leq 1$)

a_t, b_t = smoothing trend

m = forecast period

B. Single Exponential Linear Double Parameter

Two parameters exponential smoothing Holt method is the extension of the simple exponential smoothing by adding growth factors (factor trends) to smoothing equation [10]. Forecast of linear exponential smoothing Holt obtained by using two smoothing constants (with values between 0 and 1) and three equations.

$$\text{Smoothing: } S_t = \alpha Y_t + (1 - \alpha)(S_{t-1} + b_{t-1}). \quad (6)$$

$$\text{Renewal Tren: } b_t = \gamma(S_t - S_{t-1}) + (1 - \gamma)b_{t-1}. \quad (7)$$

$$\text{Forecast: } F_{t+m} = S_t + b_t(m). \quad (8)$$

where:

F_{t+m} = Forecast on the time of $t + m$

α = smoothing constant (weighting) ($0 \leq \alpha \leq 1$)

a_t, b_t = smoothing trend

m = Forecast period

The exact value for the smoothing constant (α) can make a differentiation between accurate forecast and inaccurate forecast. A high value of α is selected when the average is likely to change. A low value of α is used when the average fairly stable. Objective selection of a value for the smoothing constant is to get the most accurate forecasting [11].

C. Exponential Smoothing Forecasting

There are some calculations used to calculate the total forecast error. Three of the most famous are Mean Absolute Deviation (MAD), Mean Squared Error (MSE), and Mean Absolute Percent Error (MAPE) [11].

1) Mean Absolute Deviation (MAD)

The first measurement of the overall forecasting error for a model is called MAD. This value is calculated by taking the amount of the absolute value of any forecasting errors divided by the amount of data period (n). In MAD, errors with positive or negative results will be enforced do the same, which measured only large absolute error.

$$MAD = \frac{\sum(\text{actual}-\text{forecasting})}{n} \quad (9)$$

2) Mean Squared Error (MSE)

MSE is the squared average between predicted and observed values. MSE is the second way to measure the overall forecasting error.

$$MSE = \frac{\sum(\text{forecasting error})^2}{n} \quad (10)$$

3) Mean Absolute Percent Error (MAPE)

MAPE is calculated as the average of the absolute differentiation between the predicted and actual value, expressed as a percentage of actual value. If we had predicted and actual values for n periods.

$$MAPE = \frac{\sum \text{absolute error percentage}}{n} \quad (11)$$

D. Calculation Stock Value

Safety stock (Safety Stock) is an inventory of goods held in reserve if goods orders came much longer than the lead time [12]. The amount of safety stock is determined from the difference between the level of inventory at the reorder point with the required inventory levels during lead time. The general formula of Safety Stock for variable rate demand and constant lead time, i.e: [5]

$$SS = Z \sqrt{LT} (\sigma_d) \quad (12)$$

Where

SS = Safety Stock (unit)

Z = Service Level (100% - % risk)

σ_d = Deviation Standard of the need levels

LT = Lead Time (days)

Another approach to determining the safety stock level is using service level, i.e the percentage of time that the company will not lack supply. The service level can be used as a multiplier to calculate the standard deviation for a certain amount to meet specific service levels. For the tool used is Ms. Excel with NORM.S.INV function to convert from the shape of a percentage value. Table 1 shows the value of service level and Service Factor of several percentage value by using Microsoft Excel.

TABLE I
SERVICE LEVEL CALCULATION DAN SERVICE FACTOR

Service Level	Service Factor	Service Level	Service Factor	Service Level	Service Factor
50%	0	86%	1.08	98%	2.05
55%	0.13	87%	1.13	99%	2.33
60%	0.25	88%	1.17	99.1%	2.37
65%	0.39	89%	1.23	99.2%	2.41
70%	0.52	90%	1.28	99.3%	2.46
75%	0.67	91%	1.34	99.4%	2.51
80%	0.84	92%	1.41	99.5%	2.58
81%	0.88	93%	1.48	99.6%	2.65
82%	0.92	94%	1.55	99.7%	2.75
83%	0.95	95%	1.64	99.8%	2.88
84%	0.99	96%	1.75	99.9%	3.09
85%	1.04	97%	1.88	99.99%	3.72

Whereas standard deviation (σ_d) or standard deviation is a probability estimation of difference between real return and the expected return. The standard deviation is a measurement of the variation level of the individual probability value of the average distribution. The greater of standard deviations

obtained; therefore, the greater the risk will be accepted, and vice versa the lower of number, the smaller the standard deviation [13].

$$s = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n-1}} \quad (13)$$

Where

x_i = value of x on- i sequence

$\bar{x}$ = average of x

n = number of data used

E. Silver Meal Algorithm

The steps of determining the order numbers are using the Silver-Meal Heuristic models as follows: [14][15]

1. Count the number of booking fees and handling charges if the amount ordered is the need for the first month.

2. Count the number of booking fees and handling charges if the amount ordered is the need for the first month and the second month.

3. Continue step 2 by adding the following month needs one by one until the number of booking fees and handling preparations begin to rise. The number of best orders is from the needs at first month to the month before prior to the rising costs.

The booking fee and handling cost for various numbers of orders can be calculated using the following formula

$$AC = \frac{S + \{(1-1)D_1 + (2-1)D_2 + (3-1)D_3 + \dots + (T-1)D_T\} (I)}{T} \quad (14)$$

Where:

AC = average cost in a time unit

S = order cost or *set-up cost*

D_1 = required number on last period

I = handling stock cost in every stock unit per time unit

T = Range of period

F. Validation Limit of Determining Model Lot Size

Silver Meal algorithm is initially proposal during an EOQ with various demand. Assumptions EOQ is a constant demand. This assumption does not clearly limit variations so that the application validity of the basic EOQ model also becomes unclear [16].

Silver Meal use restrictions called Variability Coefficient (GVC). Basically, VC is a barometer of how large the demand variation of D . In other words, VC as a measurement of the extent to which EOQ is still valid used if:

a) $VC < 0.25$ thus, EOQ can be used

b) $VC \geq 0.25$ thus, EOQ is no longer valid as the demand assumption has been broken. Therefore, the Silver Meal model must be used.

Variability Coefficient is the ratio between demand variations (D) per period by the square of requests per period [14]. The greater the value of Variability Coefficient so that request variation is getting smaller; on the contrary, the smaller of Variability Coefficient so that the demand is getting varied. Mathematically, Variability Demand (D) per period are:

$$VC = -1 \frac{N \sum_{j=1}^N [D(j)]^2}{[\sum_{j=1}^N D(j)]^2} \quad (15)$$

Silver Meal method can provide a case solution for various demand. All cases are not necessarily solved by using a valid inventory EOQ, however, it needs to be tested in advanced of its Variability Coefficient to determine whether the EOQ used is valid.

G. Reorder Point (ROP)

ROP is a boundary/point number reordering including the request is desired or required during the grace period, for example, an additional/extra stock. The reorder point is usually determined by adding the use during a grace period with safety stock or in the form of the following formula: [5]

$$ROP = dLT + SS \quad (16)$$

Where:

ROP = *Reorder Point* (unit)

d = demand level average (unit)

LT = grace period (day)

SS = safety stock (unit)

III. ANALYSIS OF STOK CALCULATION

Before doing analysis, it needs to collect data as follow:

a. Data of Commodity Demand in 2013

Table 2 depicts supply demand data from January-December 2013 for five provinces in Indonesia.

TABLE 2
SUPPLY DEMAND DATA 2013

Month	Total Input + PDP (Ton)				
	Region				
	Aceh	DKI Jakarta	Kaltim	Sulut	NTB
Jan	10,000	64,106	3,496	3,992	660
Feb	13,833	3,085	1,226	2,210	2,037
March	29,177	10,318	1,905	2,674	14,185
April	33,211	20,505	9,098	4,927	33,724
May	33,836	19,259	10,262	10,216	23,679
June	10,801	12,672	5,068	8,973	11,505
July	4,507	12,323	5,055	8,145	14,350
August	7,235	7,174	1,967	9,311	11,550
September	18,777	20,832	5,320	12,732	13,815
October	17,466	14,507	4,455	4,321	11,517
November	9,211	17,015	1,133	3,393	13,462
December	7,369	9,708	1,888	7,893	12,931
Total	195,424	211,506	50,873	78,788	163,415

b. Order Cost and Raw Material Purchase

TABLE 3
Order Cost

Items	Cost (IDR) per kg	Total Cost (IDR)
Domestic (91.4 %)		
Weighting charge	9,983	366,239 (91.4%) = 334,742
Survey	1,709	
Land/Sea Movement (Average)	354,547	
International (8.6 %)		
Insurance (0.30% + 2.5 %)	9,300 (9,560)	6,982,473 (8.6%) = 600,493
Tax (+2.5 %)	450 (461)	
Karantina Exploitation	1,100	

Handling	102,586	
Survey	1,982	
Surcharge	9,300	
Flight Movement	6,857,484	
Total	7,348,712	935,235

Purchase cost as follow:

TABLE 4
PURCHASE COST

Item	Cost (IDR)	Total Cost (IDR)
Domestic Rice	4,000 (91.4%)	3,656 (per kg)
International Rice	9,300 (8.6%)	800 (per kg)
Sack Pack	1,567	1,567 (per sheet)
Total		6,022

Table 3-5 illustrates the order, purchase, maintenance, and saving cost for Aceh province.

c. Cost on Raw Material Deposit

TABLE 5
MAINTENANCE AND SAVING COST

Items	Cost (IDR)
Warehouse Administration	3,505
Reprocessing/Processing	426,000
Fumigasi	7,144
Spraying	3,122
Margin and Management	285
Total	440,056

d. Ordered Lead Time

According to the reported interview, it is stated that Lead Time for Commodity Supply is less than 10 days.

A. Forecasting with Exponential Smoothing

To choose the best forecasting method, performed by finding the smallest error value between the actual data and the forecasting results, using Mean Absolute Deviation (MAD), Mean Squared Error (MSE) and Mean Absolute Percent Error (MAPE). Here are the results of the calculation of MAD, MSE and MAPE for each forecasting method with α values which have been determined for the Aceh region (Tables 6 and 7).

TABLE 6
MAD, MSE, AND MAPE ON SMOOTHING DOUBLE EXPONENTIAL BROWN

Error value	Brown Exponential Smoothing				
	0.1	0.2	0.3	0.5	0.7
MAD	5.8E+6	5.4E+6	5.6E+6	6.8E+6	7.7E+6
MSE	5.17E+13	4.68E+13	4.5E+13	5.3E+13	7.4E+13
MAPE	66.42	70.99	72.57	81.56	93.18

TABLE 7
MAD, MSE, AND MAPE ON SMOOTHING DOUBLE EXPONENTIAL HOLT

Error value	α γ	Holt Exponential Smoothing				
		0.1	0.2	0.3	0.5	0.7
MAD	0.1	27.5E+6	20.35E+6	15.6E+6	10.33E+6	7.71E+6
MSE		1.03E+15	5.35E+14	3.11E+14	1.46E+14	9.64E+13
MAPE		384.63	275.60	208.46	139.59	109.76
MAD	0.3	23.6E+6	15.11E+6	10.34E+6	6.4E+6	6.36E+6
MSE		7.28E+14	2.92E+14	1.51E+14	7.53E+13	6.09E+13
MAPE		318.37	191.96	128.45	83.88	81.14
MAD	0.5	20.11E+6	11.09E+6	7.46E+6	6.17E+6	6.27E+6
MSE		5.17E+14	1.77E+14	9.64E+13	5.88E+13	5.61E+13
MAPE		261.34	131.64	86.35	73.39	76.11

Then compared Table 6 and 7, it can be seen in Table 8.

TABLE 8
COMPARISON MAD, MSE, AND MAPE

Error value	Forecast					
	Single Exponential	α	Brown Exponential	α	Holt Exponential	$\alpha ; \gamma$
MAD	5.27E+6	0.5	5.41E+6	0.2	6.17E+6	0.5;0.5
MSE	4.15E+13	0.5	4.56E+13	0.3	5.61E+13	0.7;0.5
MAPE	61.01	0.2	66.42	0.1	73.39	0.5;0.5

Exponential Smoothing forecasting results with Dual Linear One Parameter Brown with $\alpha = 0.2$ is shown in Table 9.

TABEL 9
FORECASTING RESULTS FOR COMMODITY DISTRIBUTION (ACEH REGION)

Month	Commodity Distribution Needs 2013 (kg)	Forecasting Results 2014 (kg)
January	928,925	9,151,540
February	8,957,800	9,243,771
March	18,269,025	9,336,001
April	11,381,725	9,428,231
May	13,122,456	9,520,462
June	7,942,266	9,612,692
July	17,849,277	9,704,922
August	6,753,130	9,797,153
September	12,886,886	9,889,383
October	8,137,618	9,981,613
November	11,702,923	10,073,844
December	3,112,144	10,166,074
Total	121,044,175	115,905,685

B. Safety Stock Calculation

Based on the forecast result in Table 9, the safety stock is then calculated using Eq. 12. Regarding on the interview results: LT (Lead Time) = 7 days = $\frac{1}{4}$ month = 0.25.

- MSR = 1.
- Z (Service Level) = 100% - risk = 99% = 2.33.
- Standard Deviation is based on actual data and forecast result.

Standard deviation of Aceh region:

$$= \sqrt{\frac{101,368,349.638}{11}} = 332,541.21$$

Therefore, Safety Stock for Aceh in 2014:

$$SS = 2.33 \sqrt{0.25(332,541.21)} = 387,411 \text{ kg}$$

TABLE 10
DEVIATION STANDARD AND SAFETY STOCK (ACEH REGION)

	Actual Data 2013	Forecasting 2014
Total	121,044,175	115,905,685
Average	10,087,014.58	9,658,807.10
Std dev	5,238,390.3	332,541.21
Lead Time	0.25	0.25
Service Level (Z)	2.33	2.33
Safety Stock	6,102,725	387,411

C. Lot Sizing Calculation with Silver Meal Algorithm

Lot Sizing technique used is based on the value of Variability Coefficient (VC) (Eq. 15).

$$VC \text{ Aceh} = 0.25$$

Then Lot Sizing technique is used to determine the optimal ordering value of Silver Meal method (Eq. 14).

Aceh Region:

- Procurement 1: 18,395,311 kg (January)
- Procurement 2: 18,764,232 kg (March)
- Procurement 3: 19,133,154 kg (May)
- Procurement 4: 19,502,075 kg (July)
- Procurement 5: 19,870,996 kg (September)
- Procurement 6: 20,239,918 kg (November)

D. Calculation on Reorder Point

ROP can give information on remaining commodity values, to make a reorder. For Aceh:

- Average of demand : 9,658,807.10 kg
- Safety Stock : 387,411 kg
- dLT : $9,658,807.10 * \frac{1}{4} = 2,414,701.78$
- ROP : dLT + SS = 2,802,112.78 kg

From the above results, Aceh must do reordering if minimal stock left in warehouses is 2,802,112.78 kg. The booking cost is made every month in 2013. Therefore, the booking fee multiplied by 12 for each year, and then compared to the reordering cost with Silver Meal Algorithm (Table 11).

TABEL 11
COMPARISON OF REORDERING COST IN ACEH

Reordering Cost of Supply Divre NAD		
Actual Data (2013) (IDR)	without Silver Meal (2014) (IDR)	Silver Meal (2014) (IDR)
114,930,475,490.88	73,435,175,931.6	57,465,237.745

Based on the comparison above, Bulog can save marketing costs in 2013 amount to:

IDR 114,930,475,490.88 - IDR 57,465,237.745

= IDR 57,465,237,745.88 that shows the efficiency as 50%.

In 2014 as:

IDR 73,435,175,931.6 - IDR 57,465,237.745

= IDR 15,969,938,186.6 that shows the efficiency as 13,90%.

V. CONCLUSION

After analyzing on stock calculation which states that the calculation result of demand forecasting using the criteria of the selection method based on the value of MAD, MSE and MAPE, then best forecasting to determine the needs of the commodity distribution and supply for next period is the Smoothing Exponential Dual One Parameter Brown Method with α at 0.2. This study proves that the Reorder Point (ROP) technique can replace the MSR (Minimum Stock Requirement) that can apply in the company. It gives evidence of cost comparison 2:7 in which MSR impact is greater cost. Silver Meal algorithm can save the supply order cost; this evident is because of less order cost, i.e when it is compared to the actual cost in 2013; it will have the difference of IDR 57,465,237,745.88 that shows 50% efficiency. In addition, if it is compared to forecasting cost in 2014 without Silver Meal application, the difference it will be IDR 15,969,938,186.6, it shows only 13.9% efficiency.

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