

Sales Forecasting Using Holt-Winters in Enterprise Resource Planning At Sales and Distribution Module

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Abstract— Enterprise Resource Planning is a system used for managing all of the resources owned by the company, business activities, and information used to make a good business process. One of the modules in the ERP is sales and distribution. Sales and distribution is a module that handles the sale and delivery goods to customers to achieve their business objective. The use sales and distribution module is intended to simplify the process of selling to customers in accordance with the interests of customers for goods and services, makes it easy to check the sale of goods and delivery of goods, and facilitate the collection of customers who make a purchase of goods or services provided by the company, determines the appropriate services to customers, and forecast the amount of demand for goods desired by the customer. Sales forecasting is calculating the expected sales of a specific product and predicting future sales of the product. It helps in making informed business decisions. In this article some several of sales forecasting methods used, Holt-Winters Additive Method, and Holt-Winters Multiplicative Method applied in ERP. The implementation of sales forecasting using Holt-Winters method in the ERP can make the system more accurate and efficient in the determination of the amount of goods demanded by customers.

Keywords—Enterprise Resource Planning (ERP), Forecasting, Holt-Winters, Sales.

I. INTRODUCTION

Sales show that the goods or services owned by a certain people exchanged for a certain amount of money or with other similar items [1]. With the sale, a company can achieve the main objectives in Business. Besides must have a strong sales function in a company, a company must also be able to distribute goods to customers quickly and efficiently, so that products sold will always be available to customers [2]. To be able to deliver goods to customers quickly and efficiently, should be followed by the distribution management goods quickly and efficiently. The use of advanced information systems that can help increase the production of goods according to the amount of goods demanded by the customer and can be distributed on time [3].

In a company, a forward planning in determining the amount of goods to be sold to customers is very important. This makes the company must have a way to be able to overcome it. One way that can be used in determining the plan is to use sales forecasting. Sales forecasting is an activity to estimate the

demand for the goods to be sold to customers within a certain time frame, sales forecast can also be used as business planning in a company in taking measures or decisions ahead [4]. Many things can affect the sales forecasts, competition among companies, customers desire for goods produced, and the influence of the global economy [5]. With the sales forecasting, the expected number of items requested by customers will increase, it also affects the production in order to produce goods in accordance with the quantity of goods demanded by customers, and by increasing the amount of goods to be manufactured, it takes time and raw materials which according to production requirements [6]. If an error occurs caused by the production of sales forecasting, it will affect the process of sale of goods to customers. Sales forecasting can also be used for the avoidance of excess or shortage of supply of goods in the warehouse, and could act as forward planning for the purchase of raw goods, budgeting, and the number of employees needed for production [7].

The aim of this article is to implement a monthly sales forecasting into the ERP system which have lowest error value. The methods used in sales forecasting is Holt-Winters Multiplicative Method and Holt-Winters Additive Method. In order to generate sales forecasting by using Holt-Winters method, it takes three basic components in the forecasting equation:

1. Level of sales, is data derived from the sales of which have been eliminated seasonal pattern, with the aim to obtain the appropriate data without the influence of other variables.
2. Trend of sales, is the change that occurs or is expected between this month and next month.
3. The seasonal index for the month to forecast.

The difference from Holt-Winter Multiplicative Method and Holt-Winters additive method contained in the use on a particular seasonal variations [8]. Holt-Winter Multiplicative Method better used if seasonal variations varies according to the data series. While Holt-Winter Additive Method is better used when seasonal variations are constant in data series [9]. Seasonal component contained in Holt-Winters additive

method is shown in absolute terms of the series of data used, and in the level equation the series is seasonally adjusted by subtracting the seasonal component. In each year, the seasonal component will increase to approximately zero. While Holt-Winters Multiplicative Method, the seasonal component is expressed in relative terms (percentages) and the series is seasonally adjusted by dividing through by the seasonal component.

II. LITERATURE REVIEW

A. Enterprise Resource Planning (ERP)

ERP is a system that can manage and define the business processes required by a company to be able to run the business objectives [10]. ERP could integrate business processes that are owned by a company. ERP is also able to plan or direct a company to take certain decisions [11] [12]. The advantages of an ERP is able to include all of the functionality and the department is in the company, ERP is also able to record all business transactions in the enterprise, monitor the performance of the company, and see the results of the report of the company [13].

B. Make To Stock Process

The business process from make to stock in the implemented ERP is started from sales forecasting. Sales forecasting created for each month after the actual data created. The results of the sales forecast used to determine the amount of raw materials to be purchased and the amount of finished goods to be produced for the next month. In addition, the sales forecast is also used to determine the number of employees who will work according to the amount of production that must be done, and also serves as a comparison between the actual budgets with the budget outcome than forecast. After the raw materials are purchased in accordance with the number forecast, followed by the production process to produce goods ready for sale.

III. METHODOLOGY

At this implementation, sales data was divided into training data set, which contain data for 60 months or 5 years start from January 2011 to December 2015 shown in TABLE 1, and testing data set, which contain data for 12 months or 1 years for the forecast result. Forecast calculated for one month ahead (monthly long-term forecasting).

Selection error measure sales forecasts are very important, because with the error measure, sales forecast results can be used or not to make the purchase of raw materials, as well as for production. Determination of error is used to determine the accuracy of the results forecast, which is formed from each of the methods used by using existing data as a measurement error. Some examples of error measure that can be used is Mean Absolute Error (MAE), Mean Absolute Percentage Error (MAPE), and Mean Squared Error (MSE).

TABLE 1. 60 MONTHS ACTUAL SALES DATA, DATA USED IN THE TABLE USING EACH FOR UNIT

Month	2011	2012	2013	2014	2015
Jan	25,187	25,937	26,477	25,386	25,983
Feb	24,810	24,774	24,965	25,084	25,804
March	20,782	23,916	23,112	22,710	21,547
April	24,169	25,370	26,352	26,488	24,398
May	25,772	24,881	25,700	24,784	26,939
June	24,922	26,181	26,849	26,552	24,598
July	28,724	28,613	29,314	28,672	27,701
Aug	25,046	26,152	26,352	26,152	25,278
Sept	29,382	28,810	28,231	27,689	28,619
Oct	25,256	24,572	24,891	25,558	26,197
Nov	24,859	26,076	25,162	25,055	25,621
Dec	29,264	27,690	27,231	28,396	28,213

A. Mean Squared Error (MSE)

MSE is a method of calculating the errors that can be used to evaluate the forecasting results. MSE calculations done by averaging the sum of the errors that have squared value corresponds to the number of existing data. calculation error using this method sets the forecasting error is large, because of each error squared value first. The MSE equation is given by (1):

$$MSE = \frac{1}{N} \sum_{t=1}^N (Y_t - F_t)^2, t = 1, 2, 3, \dots, N \quad (1)$$

Where Y_t represent actual value, F_t represent forecasted value and N represent number of samples used in data series.

B. Mean Absolute Percentage Error

MAPE is a method of calculating the errors that can be used to measure the accuracy of forecasting results. MAPE calculations done by averaging the sum of the absolute error divided by each actual data. The results shown by MAPE are usually a percentage. The MAPE equation is given by (2):

$$MAPE = \frac{1}{N} \sum_{t=1}^N \left| 100 \frac{Y_t - F_t}{Y_t} \right| [\%], t = 1, 2, 3, \dots, N \quad (2)$$

Where Y_t represent actual value, F_t represent forecasted value and N represent number of samples used in data series.

C. Mean Absolute Error

MAE is a method of calculating the error that can be used to measure how appropriate forecasting results with the end

result. MAE calculation is done by averaging the sum of the absolute value of error. The MAE equation is given by (3):

$$MAE = \frac{1}{N} \sum_{t=1}^N |Y_t - F_t|, t = 1, 2, 3, \dots, N \quad (3)$$

Where Y_t represent actual value, F_t represent forecasted value and N represent number of samples used in data series.

At this point, the lower value of the accuracy measure MSE, MAPE, and MAE represent a better forecasting performance used in sales forecasting.

IV. FORECASTING METHODS

The Holt-Winters method is like Holt's method, however in this method, the Holt-Winters method can capture seasonality in data series [14]. The Holt-Winters method consist three smoothing equations and forecast equation, where L_t is the level of sales, B_t is the trend of sales, and S_t is the seasonal component. This method also uses three smoothing parameters α , β , and γ .

A. Holt-Winters Multiplicative Method

In Holt-Winters Multiplicative Method, the equations for forecast, level, trend, and seasonal are shown in (4)-(7):

$$L_t = \alpha \left(\frac{Y_t}{S_{t-s}} \right) + (1 - \alpha)(L_t + B_{t-1}) \quad (4)$$

$$B_t = \beta (L_t - L_{t-1}) + (1 - \beta)B_{t-1} \quad (5)$$

$$S_t = \gamma \left(\frac{Y_t}{L_t} \right) + (1 - \gamma)S_{t-s} \quad (6)$$

$$F_{t+m} = (L_t + mB_t)S_{t-s+m} \quad (7)$$

Where m is the number of forecast ahead, s is the periods (months in a season), Y_t is the actual data at time point t , L_t is the level of sales at time point t , B_t is the trend of sales at time point t , S_t is the seasonal component at time point t , F_{t+m} is the forecast result for time point ahead, and where $s+m = (m - 1) \bmod m$, which indicates that seasonal forecasting component used in accordance with the last year of the data series. For smoothing parameter α , β , and γ require to in the interval $[0, 1]$.

B. Holt-Winters Additive Method

In Holt-Winters Additive Method, the equations for forecast, level, trend, and seasonal are shown in (8)-(11):

$$L_t = \alpha (Y_t - S_{t-s}) + (1 - \alpha)(L_t + B_{t-1}) \quad (8)$$

$$B_t = \beta (L_t - L_{t-1}) + (1 - \beta)B_{t-1} \quad (9)$$

$$S_t = \gamma (Y_t - L_t) + (1 - \gamma)S_{t-s} \quad (10)$$

$$F_{t+m} = L_t + mB_t + S_{t-s+m} \quad (11)$$

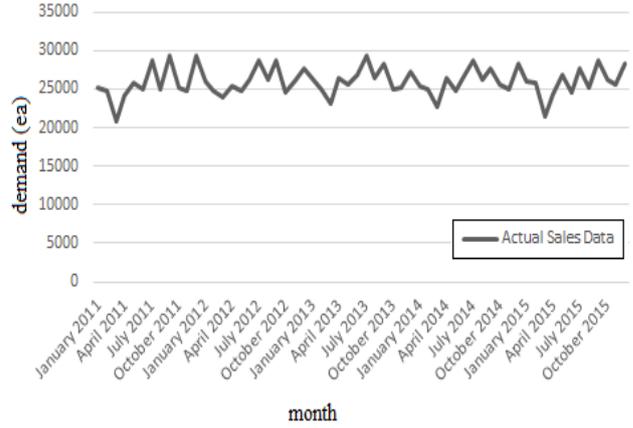


Fig. 1. 60 months actual sales data in graph

Where m is the number of forecast ahead, s is the periods (months in a season), Y_t is the actual data at time point t , L_t is the level of sales at time point t , B_t is the trend of sales at time point t , S_t is the seasonal component at time point t , F_{t+m} is the forecast result for time point ahead, and where $s+m = (m - 1) \bmod m$, which indicates that seasonal forecasting component used in accordance with the last year of the data series. For smoothing parameter α , β , and γ require to in the interval $[0, 1]$.

The level equation show a weighted average between the seasonally adjusted observation ($Y_t - S_{t-s}$) and the non-seasonal forecast ($L_t + B_{t-1}$) for time t . The trend equations is identical to Holt-Winter Multiplicative Method [15]. The seasonal equation shows a weighted average between the current seasonal index ($Y_t - L_t$), and the seasonal index of the same season last year. Difference from Holt-Winters Additive Method with Holt-Winters Multiplicative Method contained in the seasonal component, which is no longer multiplied or divided, but with a subtracted or added [16].

V. RESULT AND DISCUSSION

Forecasting value was related to the actual sales data shown in TABLE 1, where there is decreased sales in March, and the increase sales in July, September and December as shown in Fig. 1.

The results of the forecast calculation on actual sales data using holt-winters multiplicative methods shown in TABLE 2. The value of the three smoothing parameters are $\alpha = 0.389167$, $\beta = 0.068893$, and $\gamma = 0.88949$ to get the minimum error result. In TABLE 2, forecasting results for the month of January 2016 to December 2016 using Holt-Winters Multiplicative Method, respectively forecast amount will then be sent to the purchasing module and production module within the ERP system, for immediate purchase of raw materials, and undertake production. With error calculation using MAPE, MSE, and MAE shown in TABLE 3.

TABLE 2. FORECAST CALCULATION USING HOLT-WINTERS MULTIPLICATIVE METHOD, DATA USED IN THE TABLE USING EACH FOR UNIT

Month	Year 2016	Month	Year 2016
January	26,554.5	July	28,988.37
February	26,289.04	August	26,433.08
March	22,733.48	September	29,226.18
April	26,210.43	October	26,424.21
May	27,190.07	November	25,886.11
June	25,811.87	December	28,816.31

TABLE 3. ERROR CALCULATION USING HOLT-WINTERS MULTIPLICATIVE METHOD

Error Measure	Result
MAPE	4%
MSE	1,711,066
MAE	989.44

TABLE 4. FORECAST CALCULATION USING HOLT-WINTERS ADDITIVE METHOD, DATA USED IN THE TABLE USING EACH FOR UNIT

Month	Year 2016	Month	Year 2016
January	26538.06	July	28747.79
February	26312.11	August	26233.03
March	22766.66	September	28905.89
April	26156.85	October	26106.55
May	27272.95	November	25474.69
June	25653.54	December	28283.46

TABLE 5. ERROR CALCULATION USING HOLT-WINTERS MULTIPLICATIVE METHOD

Error Measure	Result
MAPE	4%
MSE	1,591,608
MAE	954.93

In And the forecast calculation on actual sales data using holt-winters multiplicative methods shown in TABLE 4. The value of the third smoothing parameters are $\alpha = 0.402995$, $\beta = 0.060976$, and $\gamma = 0.979486$ to get the minimum error result.

In TABLE 4, forecasting results for the month of January 2016 to December 2016 using Holt-Winters Additive Method, respectively forecast amount will then be sent to the purchasing module and production module within the ERP system, for immediate purchase of raw materials, and undertake production. With error calculation using MAPE, MSE, and MAE shown in TABLE 5.

Comparison between Holt-Winters Multiplicative Method and Holt-Winters Additive Method in level, trend, and seasonal shown in Fig. 2, and sales forecast comparison result shown in Fig. 3.

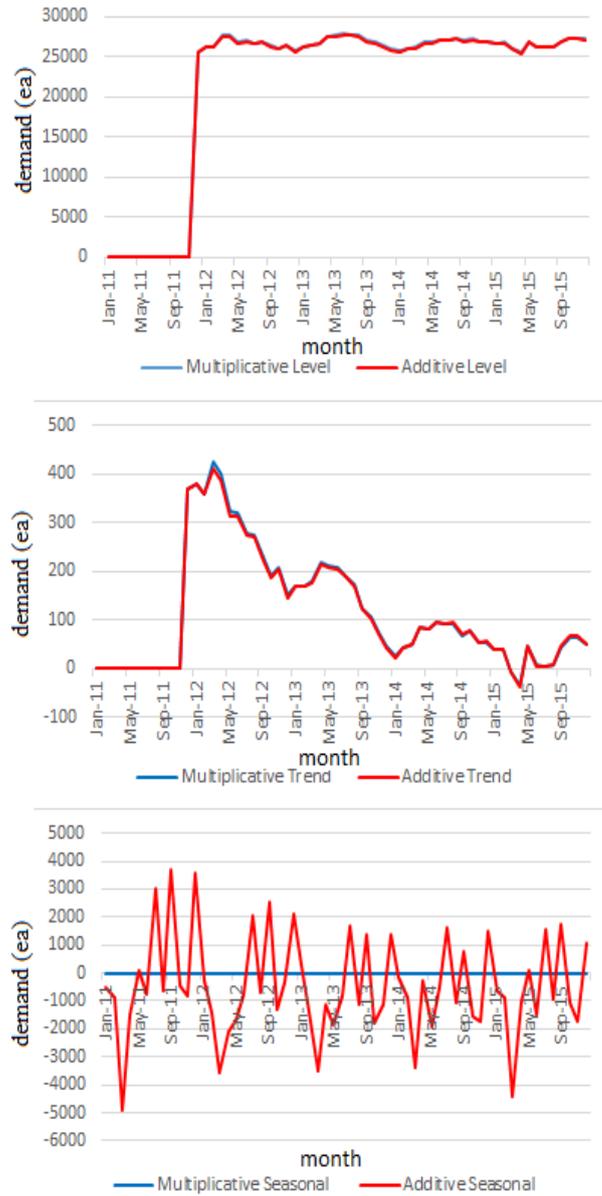


Fig. 2. Level, Trend, and Seasonal Comparison between Holt-Winters Multiplicative Method and Holt-Winters Additive Method.

Implementation into the ERP system that has been done, both method Multiplicative Holt-Winters and Holt-Winters Additive run concurrently when data has been entered into the system for both methods which generate the smallest error value. Method with the results of the smallest error selected by generating a third smoothing parameter with a value addition of 0.01 for each of the smoothing parameter, then calculate the forecast, followed by a calculation error. The results of the forecast that shown in the Fig. 3 and Fig. 4 are implemented into the ERP system.

In Fig. 2, level and trend comparison between Holt-Winters Multiplicative Method and Holt-Winters Additive Method is almost the same. While the seasonal component for Holt-

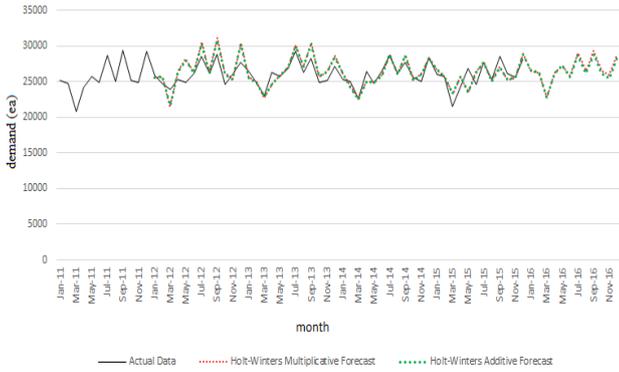


Fig. 3. Comparison forecast result between Holt-Winter Multiplicative Method and Holt-Winters Additive Method

Create Forecast

Forecast Code: Item Name: Forecast Period:

#	Forecast Date	Actual Demand	Forecast Demand	Error Ratio
1	<input type="text" value="Enter Forecast Date"/>	<input type="text" value="Enter Actual D"/>	<input type="text" value="0"/>	<input type="text" value="0"/>

Fig. 4. Form to entry actual demand in ERP system

Winters Multiplicative tend to be flat, and for the Holt-Winters Additive Method tent to be fluctuated [17]. The value of three smoothing parameters affect fluctuate of the level, trend, and seasonal component. The larger the value of α , the level that is formed will increasingly fluctuate. While, the smaller the value of α , the level that is formed will be more flat [18]. The larger the value of β , the trend that is formed will increasingly fluctuate. While, the smaller the value of β , the trend that is formed will be more flat. The larger the value of α , the trend that is formed will be more fluctuate. While, the smaller the value of α , the trend that is formed will be less fluctuate.

In Fig. 3, the forecast result for Holt-Winters Multiplicative Method and holt-Winters Additive Method is almost the same, it is because the value of level and trend for each methods is almost the same. In Fig. 4, shown a form to entry actual demand. The data must be entered in the form is what kind of product want to forecast, period of forecast, date of forecast, and the value of actual demand based on history data. In Fig. 5, the ERP system shows the value of the three smoothing parameters α , β , γ , and MAPE to inform user about the sales forecast result.

In Fig. 6, shown the result of the sales forecast in the ERP system from January 2016 to December 2016. Decimals value in forecast results must be removed, because the goods will be produced in number must be an integer.

Red Deluxe Forecast

Forecast Code	Red Deluxe Forecast	Forecast Periods	30
Item Name	Red Deluxe Touring Bike	Forecast Error (MAPE)	4%
		Forecast Alpha	0.4
		Forecast Beta	0.06
		Forecast Gamma	0.97

Fig. 5 MAPE, α , β , and γ result in ERP system

#	Forecast Date	Actual Demand	Forecast Demand
1	Jan 1, 2016	(not set)	26536
2	Feb 1, 2016	(not set)	26303
3	Mar 1, 2016	(not set)	22763
4	Apr 1, 2016	(not set)	26148
5	May 1, 2016	(not set)	27254
6	Jun 1, 2016	(not set)	25660
7	Jul 1, 2016	(not set)	28748
8	Aug 1, 2016	(not set)	26234
9	Sep 1, 2016	(not set)	28906
10	Oct 1, 2016	(not set)	26110
11	Nov 1, 2016	(not set)	25481
12	Dec 1, 2016	(not set)	28288

Fig. 6. Forecast result from ERP system

VI. CONCLUSION

The use of sales forecasting at an ERP to forecast customer demand is very effective. With the sales forecasting on an ERP, production of goods can be set according to customer requirements as well as the capability of a warehouse to store goods, so it does not overstock or understock, and could act as forward planning for the purchase of raw goods, budgeting, and the number of employees needed for production.

Holt-Winters methods can be used in the sales forecast when the actual data has a trend and seasonality. The difference from Holt-Winter Multiplicative Method and Holt-Winters additive method contained in the use on a particular seasonal variations. Holt-Winter Multiplicative Method better used if seasonal variations varies according to the data series. While Holt-Winter Additive Method is better used when seasonal variations are constant in data series and Holt-Winters have three smoothing parameters and can capture seasonality. Smoothing parameters, α , β and γ are used as parameter that can

be adjusted to make minimum error result. The error measure used for selecting the best forecast is MAPE, MSE, and MAE.

Holt-Winters Multiplicative Method MAPE is 4%, MSE is 1,711,066, and MAE is 989.44. Holt-Winters Additive Method

sales forecast in the ERP system can be run well. When the forecast is created, then the raw materials to be purchased shall be immediately informed to the purchasing module and in the production module, the result of sales forecasting will inform to make finished goods according to the amount forecast given. With the Holt-Winters method to sales forecasts in an ERP system, will facilitate the determination of the amount of raw materials to be purchased, and the number of items that must be produced, so that the distribution of goods to the customer will always be available.

A. Upcoming plan

For the upcoming ERP development, there will be another external influencing factor such as general economic condition, industrial behaviors, etc. which cannot be handled by Holt-Winters forecasting in this ERP at this time.

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