

The System of Inventory Forecasting in PT. XYZ by using the Method of Holt Winter Multiplicative

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Abstract. Problems at PT. XYZ currently only rely on manual bookkeeping, then the cost of production will swell and all investments invested to be less to predict sales and inventory of goods. If the inventory prediction of goods is too large, then the cost of production will swell and all investments invested to be less efficient. Vice versa, if the inventory prediction is too small it will impact on consumers, so that consumers are forced to wait for the desired product. Therefore, in this era of globalization, the development of computer technology has become a very important part in every business plan. Almost of all companies, both large and small, use computer technology. By utilizing computer technology, people can make time in solving complex business problems. Computer technology for companies has become an indispensable activity to provide enhancements to the business services they manage but systems and technologies are not limited to the distribution model and data processing but the existing system must be able to analyze the possibilities of future company capabilities. Therefore, the company must be able to forecast conditions and circumstances, either from inventory of goods, force, or profits to be obtained. To forecast it, the data of total sales from December 2014 to December 2016 will be calculated by using the method of Holt Winters, which is the method of time series prediction (Multiplicative Seasonal Method) it is seasonal data that has increased and decreased, also has 4 equations i.e. Single Smoothing, Trending Smoothing, Seasonal Smoothing and Forecasting. From the results of research conducted, error value in the form of MAPE is below 1%, so it can be concluded that forecasting with the method of Holt Winter Multiplicative.

1. Introduction

Forecasting is a prediction for predicting future circumstances using historical data and certain techniques calculated based on mathematical calculations for future decisions. Forecasting is very important for many investment decisions, such as asset allocation and risk management [1]. A forecasting approach is required to deal with stationary or non-stationary data, enabling it to support accurate decisions in a competitive environment [2]. The inventory control system assumes that estimation errors are usually distributed and unbiased. This is often violated in practice. Barrow et al investigated whether the combination of forecasts led to an improvement in the shape of the distribution of errors against the nature of normality and ignorance desired [3]. XYZ Company currently only rely on manual bookkeeping to predict sales and inventory. If the inventory prediction is too large, the production cost will swell and all the investments invested become less efficient. Vice versa, if the inventory prediction is too small it will impact on consumers so forced to wait for the desired product.



Accurate forecasting systems are an efficient way to design sales strategies, improve customer satisfaction, reduce product damage, increase sales revenue and design production plans.

Research on forecasting based on time series has been done as: Holt Winter Multiplicative [4]. This time series factor has repeatable features at certain time intervals. The factor is the Holt Winter Multiplicative which depends on the characteristic of the series where there are seasonal components. [5]. The Holt Winter Multiplicative method is effective in forecasting tourist arrivals where tourist arrivals contain seasonal variations [6]. Multiplicative seasonal models are used when data has multiplicative seasonality. Multiplicative models are more often implemented in computer forecasting software [7]. The Holt Winter Multiplicative approach is better than additives, in addition to the initial values for the components, trends and seasonal components as well as the three smoothing constants (Alpha, Beta and Gamma) as a constant variable [8]. There are two important criteria to test forecasting accuracy: MAD, MSE, and MAPE [9]. The advantage of the Holt Winter Multiplicative method is that it has excellent ability to forecast data that has trend and seasonal patterns. This method is used to forecast an outcome tailored to the trend and seasonal variations that cannot be overcome by moving average method and exponential smoothing method. The Holt Winter Multiplicative method provides three parameters to refine the value, i.e. stationary, trend, and seasonal. The goal is to find out whether the implementation of the Holt Winter Multiplicative method is capable of handling the company's problems. Know the pattern of historical data on the company to do the forecasting with Holt Winter Multiplicative method into the inventory forecasting system PT. XYZ. Then the latter knows the accuracy of the results of Holt Winter Multiplicative forecasting system for inventory forecasting PT. XYZ.

2. Methods

This research is carried out with the following stages:

2.1. Early stage

- a. Determine the location of the study
In this research, the research location is PT. XYZ
- b. Determining the problems that exist in PT. XYZ Urgency of this research is to produce a system that can help forecasting company inventory. This stage is done by observation and interview directly to the owner of this company.

2.2. Literature study stage

- a. Learn the company's inventory system the inventory system is studied with data from interviews and observations of the inventory processes directly.
- b. Learn the Holt Winter Multiplicative Method Learn this method by searching from various sources of reference and information references from books, papers, articles and more.
- c. Determining data needs
Data required in this research is historical data of goods sales transaction from December 2014 until December 2016.

2.3. Data processing stage

- a. Monthly sales data distribution into weekly sales data Sales data on this company in the form of monthly sales data. Data is divided into 4 periods, namely: 1 to 1-week period.
- b. Initialize data into training data and data testing at this stage, the data series (splitting data) is divided into 2 parts: Data training and Data testing. Based on the Pareto principle, the data is divided into 80:20 ratio, i.e. 80% for training data and 20% for data testing from historical data of sales of each product

2.4. Implementation of holt winter multiplicative method

- a. Initialize the value of alpha, beta, gamma of each product.

- Alpha value is constant for single smoothing then in this research has been determined equal to 0,9 where with value of alpha 0,9 got MAPE value (Mean Absolut Percentage Error) below 1%.
 - Beta value is constant for smoothing trend then in this research has been determined equal to 0,1.
 - Gamma value is a constant for seasonal smoothing which then in this research is determined by 0,1.
- b. Single smoothing data calculation
Single smoothing is the basic formulation of Holt Winter Multiplicative forecasting used for stationary elements.
 - c. Trend smoothing data calculation
The second smoothing equation is the smoothing of trends which is the basic formulation of Holt Winter Multiplicative forecasting used for trending elements.
 - d. Calculation of seasonal smoothing data the third smoothing equation carried out is seasonal smoothing which is the basic formulation of Holt Winter Multiplicative forecasting used for seasonal elements.
 - e. Calculation of inventory forecasting
The calculation of the data value forecasting result (F_t) starts from the initialization data of the second period which has initial values (S_4 , b_4 , and I_1 up to I_4). Thus, the first data forecasting result (F_5) is obtained.
 - f. Mean Absolute Deviation (MAD) is the step of calculating the average forecasting error
 - g. Mean Square Error (MSE) is the stage of calculating the middle value of the quadratic error
 - h. MAPE (Mean Absolute Percentage Error) is the calculation stage of the average absolute percentage error.

2.5. *Software development*

Software development using the linear sequence / waterfall process model, the stage is:

- a. Analysis
At the stage of analysis carried out the process of gathering needs by way of interviews or observation.
- b. Design
At this stage is a multi-step process that focuses on the design of software development using a structured programming design.
- c. Coding
The resulting design will be translated into the software program code. The result of this stage is a computer program that matches the design that has been made at the design stage.
- d. Testing
Testing stages focus on software to minimize errors (bugs and program bugs) and ensure results that match what the company wants.

2.6. *Smoothing training*

The smoothing training process is a combination of single smoothing, trend, seasonal calculations presented in the form of tables and graphs that describes the comparison between actual data and predicted data using the Holt Winter Multiplicative method to produce Mean Absolute Deviation (MAD) error, Mean Square Error (MSE), and MAPE (Mean Absolute Percentage Error).

3. Results and discussion

This research is conducted to forecasting inventory data with onyx ivory and crystal goods. The main approach used for initialization of values on the smoothing method, one of which is with the data split (data split). By using the Pareto Principle (80:20).

3.1. Initialize Alpha, Beta, and Gamma

Initialization of alpha, beta and gamma values is the first step in forecasting using the holt winter multiplicative method. The selected value of alpha, beta and gamma is 0.9; 0.1 and 0.1. Determination of the value is done because it has the smallest error value compared with other values in the range 0.1 - 0.9.

3.2. Single sling (stationary data)

3.2.1. Onyx's forecasting. In forecasting Onyx based on historical data Onyx sales, single smoothing first determined the value of initialization by averaging the first 4 periods.

$$S_{(4)} = \frac{1}{4}(47 + 71 + 68 + 105)$$

So as to generate a value of 72.75 as a single smoothing initialization value (S4). Furthermore, the value of S5 is obtained based on a single smoothing formula to obtain the following values:

$$S_5 = 0,9 (62/0,65) + (1 - 0,9) (72,75 + 6,5) = 94,30$$

Single smoothing is done using the same formula up to the last t value i.e.

$$S_{100} = 0,9 (112/1,29) + (1 - 0,9) (88,57 + 1,29) = 86,99$$

3.2.2. Ivory's forecasting. In Ivory forecasting based on historical data of Ivory sales, a single smoothing is determined first by its initialization value by averaging the first 4 periods.

$$S_{(4)} = \frac{1}{4}(33 + 28 + 21 + 31)$$

So as to produce a value of 28.25 as the initialization value of single smoothing (S4). Furthermore, the value of S5 is obtained based on a single smoothing formula to obtain the following values: Single smoothing is done using the same formula up to the last t value i.e.

$$S_{100} = 0,9 (28/0,99) + (1 - 0,9) (62,86 + 2,51) = 30,85$$

3.2.3. Crystal's forecasting. In Crystal forecasting based on Crystal's historical sales data, a single smoothing is determined first by its initialization value by averaging the first 4 periods.

$$S_{(4)} = \frac{1}{4}(32 + 22 + 20 + 27)$$

So as to generate a value of 25.25 as a single smoothing initialization value (S4). Furthermore, the value of S5 is obtained based on a single smoothing formula to obtain the following values:

$$S_5 = 0,9 (26/1,27) + (1 - 0,9) (25,25 + 0) = 26,06$$

Single smoothing is done using the same formula up to the last t value i.e.:

$$S_{100} = 0,9 (29/0,96) + (1 - 0,9) (59,04 + 1,97) = 31,19$$

3.3. Trending smoothing (b)

3.3.1. Onyx's forecasting. In forecasting based on historical data of Onyx sales, smoothing trend is determined first value initialization using data from period 1 to 2L period, with the following calculation.

$$b_4 = \frac{1}{4} \left[\frac{62 - 47}{4} + \frac{101 - 71}{4} + \frac{129 - 68}{4} + \frac{103 - 105}{4} \right]$$

So, it generates a value of 6.5 as the initialization value of trend trending (b4). Further, the value of b5 is obtained based on a single smoothing formula, to obtain the following values:

$$b_5 = 0,1 (94,30 - 72,75) + (1 - 0,1) (6,5) = 8,00$$

Trend smoothing is done using the same formula up to the last t value, so the following values are obtained:

$$b_{100} = 0,1 (86,99 - 88,57) + (1 - 0,1) (-2,35) = -2,27$$

3.3.2. Ivory's forecasting. In forecasting based on historical data of Ivory sales, smoothing trend is determined first value initialization using data from period 1 to 2L period, with the following calculation:

$$b_4 = \frac{1}{4} \left[\frac{27 - 33}{4} + \frac{25 - 28}{4} + \frac{26 - 21}{4} + \frac{36 - 31}{4} \right]$$

So as to generate a value of 0.06 as the initialization value of trend trending (b4). Further, the value of b5 is obtained based on a single smoothing formula, to obtain the following values:

$$b_5 = 0,1 (27,13 - 28,25) + (1 - 0,1) (0,06) = -0,41$$

Trend smoothing is done using the same formula up to the last t value, so the following values are obtained:

$$b_{100} = 0,1 (30,85 - 62,86) + (1 - 0,1) (2,51) = -0,82$$

3.3.3. Crystal's forecasting. In forecasting based on Crystal's historical sales data, trend smoothing is determined first by initializing the value using data from period 1 to 2L, with the following calculation.

$$b_4 = \frac{1}{4} \left[\frac{26 - 32}{4} + \frac{27 - 22}{4} + \frac{22 - 20}{4} + \frac{26 - 27}{4} \right]$$

So, it produces a value of 0 as the initialization value of trend trending (b4). Further, the value of b5 is obtained based on a single smoothing formula, to obtain the following values:

$$b_5 = 0,1 (20,99 - 25,25) + (1 - 0,1) (0) = -0,43$$

Trend smoothing is done using the same formula up to the last t value, so the following values are obtained:

$$b_{100} = 0,1 (31,19 - 59,04) + (1 - 0,1) (1,97) = -0,80$$

3.4. Seasonal smoothing (i)

3.4.1. Onyx's forecasting. In forecasting based on historical data of Onyx sales, seasonal smoothing is determined first by initialization value by dividing the value of the first 4 data with the result from the average of 4 data.

$$I_{(1)} = \frac{47}{72,75}, \quad I_{(2)} = \frac{71}{72,75}, \quad I_{(3)} = \frac{68}{72,75}, \quad I_{(4)} = \frac{105}{72,75}$$

So, each yields a value of $I_1 = 0.65$, $I_2 = 0.98$, $I_3 = 0.93$, $I_4 = 1.44$, as the initialization value of seasonal smoothing. Furthermore, the value of I_5 is obtained based on the seasonal smoothing formula, so the following values are obtained:

$$I_5 = (0,1 (62/94,30)) + (1 - 0,1) 0,65 = 0,65$$

Seasonal grinding is done using the same formula up to the last t value, so the following values are obtained:

$$I_{100} = (0,1 (112/86,99)) + (1 - 0,1) 1,29 = 1,29$$

3.4.2. Ivory's forecasting. In forecasting based on historical data of Ivory sales, seasonal smoothing is determined first by initialization value by dividing the value of the first 4 data with the result from the average of 4 data.

$$I_{(1)} = \frac{33}{28,25}, \quad I_{(2)} = \frac{28}{28,25}, \quad I_{(3)} = \frac{21}{28,25}, \quad I_{(4)} = \frac{31}{28,25}$$

So, each yields a value $I_1 = 1,17$, $I_2 = 0,99$, $I_3 = 0,74$, $I_4 = 1,10$, As the initialization value of seasonal smoothing. Furthermore, the value of I_5 is obtained based on the seasonal smoothing formula, so the following values are obtained

$$I_5 = (0,1 (27/27,13)) + (1 - 0,1) 1,17 = 1,17$$

Seasonal grinding is done using the same formula up to the last t value, so the following values are obtained:

$$I_{100} = (0,1 (28/30,85)) + (1 - 0,1) 0,99 = 0,98$$

3.4.3. Crystal forecasting. In forecasting based on Crystal's historical sales data, seasonal smoothing is first determined by initialization value by dividing the value of the first 4 data with the result from the average of 4 data.

$$I_{(1)} = \frac{32}{25,25}, \quad I_{(2)} = \frac{22}{25,25}, \quad I_{(3)} = \frac{20}{25,25}, \quad I_{(4)} = \frac{27}{25,25}$$

So, each yields a value of $I_1 = 1.27$, $I_2 = 0.87$, $I_3 = 0.79$, $I_4 = 1.07$, as the initialization value of seasonal smoothing. Furthermore, the value of I_5 is obtained based on the seasonal smoothing formula, so the following values are obtained:

$$I_5 = (0,1 (26/26,06)) + (1 - 0,1) 1,27 = 1,26$$

Seasonal grinding is done using the same formula up to the last t value, so the following values are obtained

$$I_{100} = (0,1 (29/31,19)) + (1 - 0,1) 0,96 = 0,95$$

3.5. Forecast

3.5.1. Onyx's forecasting. In forecasting based on historical data Onyx sales, obtained data value of the first forecasting results (F_5), that is:

$$F_5 = (94,30 + 8) (1) 0,65 = 66,09$$

Holt Winter Multiplicative Forecasting of historical data of Onyx sales, conducted using the same formula up to the last t value, so obtained the value of the calculation as follows:

$$F_{100} = (86,99 + (-2,27) (1)) 1,29 = 108,97$$

3.5.2. Ivory's forecasting. In forecasting based on historical data of Ivory sales, the first forecasting data (F_5) is obtained, that is:

$$F_5 = (23,63 + (-0,41)) (1) 1,17 = 27,13$$

Holt Winter Multiplicative Forecasting of historical data of Ivory sales, carried out using the same formula up to the last t value, so obtained the value of the calculation as follows:

$$F_{100} = (32,07 + (-0,82) (1)) 0,98 = 30,85$$

3.5.3. Crystal's forecasting. In forecasting based on historical sales data Crystal, obtained the value of the first forecasting data (F_5), that is:

$$F_5 = (20,99 + (-0,43)) (1) 1,26 = 26,06$$

Holt Winter Multiplicative forecasting of Crystal's historical sales data, carried out using the same formula up to the last t value, to obtain the value of the calculation

$$F_{100} = (33,28 + (-0,80) (1)) 0,95 = 31,19$$

3.6. Error

3.6.1. Onyx's forecasting. In forecasting based on Onyx's historical sales test data, the values of MAD, MSE, MAPE as follow:

$$\text{MAD} = \frac{77,82}{20} = 3,89$$

$$\text{MSE} = \frac{598,3068}{20} = 29,91$$

$$\text{MAPE} = \frac{4,588}{20} = 0,23\%$$

3.6.2. *Ivory's forecasting.* In forecasting based on Ivory's historical sales test data, the values of MAD, MSE, MAPE as follow:

$$\text{MAD} = \frac{12,84}{20} = 0,64$$

$$\text{MSE} = \frac{13,7092}{20} = 0,69$$

$$\text{MAPE} = \frac{2,281}{20} = 0,11\%$$

3.6.3. *Crystal's forecasting.* In forecasting based on Crystal's historical sales test data, the values of MAD, MSE, MAPE as follow:

$$\text{MAD} = \frac{12,06}{20} = 0,60$$

$$\text{MSE} = \frac{11,551}{20} = 0,58$$

$$\text{MAPE} = \frac{1,964}{20} = 0,10\%$$

Holt Winter Multiplicative Method using fluctuating data for accurate forecasting results with MAPE below 1%.

4. Conclusion

Problems in the company can be solved by Holt Winter Multiplicative method because by using this method and data that is fluctuate with the result of accurate forecasting with MAPE below 1%. The results of this study reduce the occurrence of the classic problem of inventory that is over stock or stock out.

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