Demand Forecasting with Five Parameter Exponential Smoothing

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Abstract. Changes in technology has affected many aspects on economic development. One of them is Newspaper Industry. Reports indicate that globally the newspaper is passing through its hardest time ever. Therefore, newspaper industry need to be more creative in order to be able to deal with change and maintain its existence. In supply chain management newspaper industry, forecasting is the most important part to predict the future demand, minimize waste of product, scheduling production, optimize inventory level and resources. The exponential smoothing methods are simple but the best approach and popular methods used for forecasting. This study aimed to implement five parameter exponential smoothing to predict number of newspaper demand in the future with various method to get the best forecast result. The performance of method is evaluated using a newspaper demand daily time series. MSD and MSE used to determining and selecting the best forecasting method. The result show that additive Holt winters method with damped trend (DAHWM) is suitable for demand forecasting in newspaper industry.

1. Introduction
Changes in technology has affected many aspects on economic development. Tight competition in the business world almost occurs in various types of industries, one of them is the newspaper industry. Reports indicates that globally, the newspaper industry is currently passing through its hardest time ever. Based on [1] survey conducted in 11 main cities in Indonesia, electronic media penetration still leading compared to print media and also the survey show that newspaper had unpredictable demand. This can happen because it was influenced by several factors such as weather, topic and etc. This is a challenge for newspaper industry to be more creative in order to be able to maintain its existence.

To overcome these difficulties, it is necessary to predict the possibility of a decrease or increase in the future demand. In supply chain management newspaper industry, forecasting is the most important part to predict the future demand, minimize waste of product, scheduling production, optimize inventory level and resources. Proper demand forecasting gives information about their market, so the managers could make business strategies. Without demand forecasting, managers have risk to make poor decisions about their products and target and have an effect on customer satisfaction and profitability.

In a case study of newspaper industry, the company implemented that the production has no inventory (Zero inventory) because the information in the newspaper cannot be sold tomorrow. The company need to do the forecast demand because inaccuracies and unpredictable demand on the next production can cause waste production [2]. Beside that, forecasting can help the decision making to solve the problems[3]. Forecasting demand can be done with various method such as Autoregressive(AR), Moving Average(MA), Autoregressive Moving Average(ARMA), Autoregressive Integrated Moving Average (ARIMA), and Exponential Smoothing(ES) [4].
In the forecasting demand, The exponential smoothing methods are simple but the best approach and popular methods used for forecasting. They are widely used for forecast demand for inventories[5]. They have also formed surprisingly well in forecasting competitions[6][7]. Three basic exponential smoothing was introduced by [8] and [9]. [8] extended it to linear exponential smoothing to allow forecasting of data with trends and seasonal. His method was studied by [10] so its called Holt Winters Method. Later the methods have been adapted and used to time series data with multiplicative trends by[11], damped trend [12],[13] and recently have been adapted to time series with multiple seasonal periods[14].

Based on the statement that has been described, this research raises the problem about predicting newspaper demand using exponential smoothing method and extended exponential smoothing method that developed by[15]. This study aimed to implement five parameter exponential smoothing to predict number of newspaper demand in the future with various method to get the best forecast result. The methods has been done to forecast the telecommunication data[16], online imaging of biospeckle [17] urban water ecological footprint [18], electricity energy consumption[19], Inventory Control[20], Solar Irradiance [21], Two product and two echelon supply chain[22], Production Schedule[23], Urban Arterial Street[24]. The exponential smoothing method consist of five parameters exponential smoothing which is the Additive Exponential Smoothing, Multiplicative Exponential Smoothing, Additive Exponential Smoothing Method With Damped Trend, Multiplicative Exponential Smoothing Method With Damped Trend And Extended Exponential Smoothing Method.

2. Methodology

This study used real demand series from newspaper company. In this study, Exponential Smoothing Method used to forecast the future demand. The analysis was used Excel Solver to estimate the optimal smoothing parameter. There are several steps of this study. First, initialization and estimation smoothing methods consist to set the initial values for the level, slope and seasonal index and the values for the smoothing parameters, then calculate the future demand using five parameters Exponential Smoothing. Third, compare the accuracy of forecast, then simulated time series. Forecasting the future demand need to use the historical data to get the best and relevant estimates prediction. The data used was historical demand from July-December 2017, consist of 184 days.

Exponential Smoothing Methods consist of notation \( l_p \) an estimate of the level series at time \( p \), \( t_p \) an estimate of the trend of the series at time \( p \), \( s_p \) an estimate of the seasonal factors at time \( p \). In this study \( Y_{p+h} \) used to denote a point forecast of \( Y_{p+h} \) at time \( p \). one complete season consist of \( m \) periods \( (m = 184 \) for daily time series). The degree of smoothing is determined by the smoothing parameter \( (\alpha, \beta, \gamma) \) which takes value between 0 and 1. The constant \( \alpha \) used to control the smoothing of \( l_p \), \( \beta \) to modifies trend component of \( t_p \) and \( \gamma \) to modified seasonal component of \( s_p \). After selecting the constants, the next step is calculating the Exponential Smoothing equation. The five parameter Exponential Smoothing Method is as follow :

2.1. Classical Exponential Smoothing Method

Classical Exponential Method based on level, trend and seasonality[21]. There are two variants.

The Additive Exponential Smoothing Method (AESM) is useful when the data have some zero entries and individual products. The basic equation is as follow:

\[
\begin{align*}
l_p &= \alpha(y_p - s_{p-m}) + (1 - \alpha)(l_{p-1} + b_{p-1}) \\
t_p &= \beta(l_p - l_{p-1}) + (1 - \beta)t_{p-1} \\
s_p &= \gamma(y_p - l_p) + (1 - \gamma)s_{p-m} \\
Y_{p+h} &= l_p + ht_p + s_{p-m+h}m
\end{align*}
\]
The Multiplicative Exponential Smoothing Method (MESM) is useful when the data must be positive but cannot be used when the data have some zero entries, and individual products [25]. The basic equation is as follows:

\[ l_p = \alpha \left( \frac{y_p}{s_{p-m}} \right) + (1 - \alpha)(l_{p-1} + b_{p-1}) \]  

\[ t_p = \beta(l_p - l_{p-1}) + (1 - \beta)t_{p-1} \]  

\[ s_p = \gamma \left( \frac{y_p}{l_p} \right) + (1 - \gamma)s_{p-m} \]  

\[ Y_{p+hit} = (l_p + \phi h_{p+hit})s_{p-m+hm} \]  

2.2. Exponential Smoothing Method with Damped Trend

[26] added a new parameter to \( l_p \) and \( t_p \) an that dampens the trend to a flat line in the future.

The recurrence and forecasting equation for the Additive Exponential Smoothing Method with Damped Trend (DAESM) is as follow:

\[ l_p = \alpha(y_p - s_{p-m}) + (1 - \alpha)(l_{p-1} + \phi t_{p-1}) \]  

\[ t_p = \beta(l_p - l_{p-1}) + (1 - \beta)\phi t_{p-1} \]  

\[ s_p = \gamma(y_p - l_p) + (1 - \gamma)s_{p-m} \]  

\[ Y_{p+hit} = (l_p + \phi h_{p})s_{p-m+hm} \]  

2.3. Extended Exponential Smoothing Method (EESM)

EESM was developed by [15] with added a new parameter \( \delta \) to the \( l_p \) equation to smooth the seasonal factors, depending on the value of the parameter. If \( \delta = \alpha \), the EESM reduce the AESM. If \( \delta = 1 \), the EESM improved Exponential Smoothing Method. The equation for the Extended Exponential Smoothing Method with Damped Trend (EESM) is as follow:

\[ l_p = \alpha(y_p - \delta s_{p-m}) + (1 - \alpha)(l_{p-1} + \phi t_{p-1}) \]  

\[ t_p = \beta(l_p - l_{p-1}) + (1 - \beta)\phi t_{p-1} \]  

\[ s_p = \gamma(y_p - l_p) + (1 - \gamma)s_{p-m} \]  

\[ Y_{p+hit} = (l_p + \phi h_{p} t_{p})s_{p-m+hm} \]  

For \( \phi = 1 \) the damped method reduce the result and can be used as the benchmark forecasting[27].
3. Result and Discussion
This study used real demand time series from newspaper company. In this study, Exponential Smoothing Method used to forecast the future demand. These following picture figures out Newspaper Demand Time Series Graph.

![Figure 1. Time Series Plot of Demand](image1)

From figure 1, it can be seen that the historical demand has an increase and decrease data over the time and forms trend data patterns. In addition, the graph is also have seasonally pattern every seven days, because in the first day until the six day the data has increase and will be decrease in the seventh day and increase again in the eight day. The fluctuation of data depends on the intention to read newspaper and the newspaper has decreased on Sunday, because its a day off from work and just a few readers have outside activities.

The goal of Exponential Smoothing Method is to predict the future demand newspaper. In forming the score of constanta Alfa($\alpha$), Beta($\beta$), Gamma($\gamma$), solver excel was used to find the optimal result.

![Figure 2. Comparison forecasting 7 days future demand](image2)

According to the result, there is no significant difference in Predicting demand using five parameters, which confirms good model prediction. So, it can be said that it’s hard to choose among the five parameters. Since it’s not possible to choose just by the forecast result, smoothing error was used to evaluate the accuracy of forecast. To evaluate accuracy forecast used Mean Absolute Deviation (MAD) and Mean Standard Error (MSE). The chosen value of smoothing methods shown by the lowest value of mean square error of forecast. The comparison forecast accuracy shown in the following table.

| Parameter | Method                  | ADDITIVE | MULTIPLICATIVE | ADDITIVE DAMPED | MULTIPLICATIVE DAMPED | EXTENDED |
|-----------|-------------------------|----------|----------------|-----------------|-----------------------|----------|
| MAD       | 689                     | 3002     | 675            | 837             | 737                   |
| MSE       | 1056161                 | 1073746  | 1038814        | 1530006         | 1068057               |

Based on table 1, the smallest MSD and MSE value is 675 and 1038814. The smallest value obtained by forecasting using DAES Method. Figure 3 show the comparative realized demand with forecasting value using DAESM Method. It can be seen that the different between the actual and forecast data are not significant and it can be use for prediction in the future days.
4. Conclusion

In this paper, we have implemented four parameters exponential smoothing method in newspaper industry. We used 184 days time series from newspaper industry. From all of the four methods considered, the best results forecast were achieved by Additive holt winters method with damped trend. The result show that newspaper industry still have more readers, this is indicated by the demand for seven days ahead. The demand has decreased on the day seven its because newspaper industry have a seasonality index and trends that can occur every seven days. This can happen because it was influenced by several factors such as weather, topic, costumer preference, weekdays, and etc.

The demand forecasting results is a good way to anticipate what customers want in the future so the company can prepare the raw materials and resource to meet the demand, cut down cost and other operational expenses then they are not needed, make a production schedule, and it also gives information about their sales to the managers, so they could make a new strategies to expand the business. Although forecast demand has been done with various methods, however, there is still lack of control that the demand for newspaper are influenced by other variables such as headline news, the weather, etc. Further research can be done by considering several variables that can affect the newspaper demand.

5. References

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