21-Brown

By Jaka Nugraha
BROWN’S WEIGHTED EXPONENTIAL MOVING AVERAGE (B-WEMA) WITH LEVENBERG-MARQUARDT OPTIMIZATION TO FORECASTING RATE OF RETURN

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ABSTRACT
Infrastructure became the main focus of the government that resulted in the construction of the role of the Indonesian economy. The construction sector is also believed to be unaffected by the political issues. In fact, construction businessmen predict this sector will develop in 2018. One of the largest construction companies in Indonesia is PT. AdhiKarya (Persero) Tbk, which shares are corrected or called buy on weakness. So investors can get the bottom price, although the stock prices are down but it potentially going up. In this paper, the authors combined methods of Weighted Moving Average and Brown’s Double Exponential Smoothing. The combination of two methods called Brown’s Weighted Exponential Moving Average. The authors used 256 PT. Adhi Karya (Persero) Tbk (ADHIJK) stock closing data, taken daily from March 1st, 2017 to March 1st, 2018. Optimization of alpha parameters uses software R with Levenberg-Marquardt algorithm yields an optimization value of alpha parameter of 0.445175. The comparison of the three methods says that Brown’s Weighted Exponential Moving Average is the best method, because it has the smallest MSE and MAPE value. The results of the best forecasting method uses to forecast the rate of return that yields a value of 0.0082%, 0.0138%, -0.0082% for next three periods with the average rate of return a value of 0.0809%, that means during the investment year, investors get a profit of 0.0226% per day from the total funds invested in stock PT. Adhi Karya (Persero) Tbk.

Keywords: Weighted Moving Average, Brown’s Double Exponential Smoothing, Brown’s Weighted Exponential Moving Average Optimization Levenberg-Marquardt, Rate of Return

Introduction
A time series is a main set of observation orders by time. In the very simple case, a time series is a sequence of recorded values of one variable that taken at equally spaced time points [1]. For example, the (time ordered) sequence of daily closing prices of PT. Adhi Karya (Persero) Tbk (ADHIJK) is a time series data. Time series can be found in the fields of engineering, science, sociology, and economics. Time series analysis is a branch of statistics which deals with techniques that develops for drawing inferences from time series. The first step in the analysis of a time series is the selection of a suitable model (or class of models) for the data.

A weighted moving average is the average value which has multiplying factors to give a different weight to data at different positions in the sample window. Mathematically the moving average is the convolution of the datum points with a fixed weighting function. The application uses for removing pixelization from digital graphical image. In technical analysis of financial data, a weighted moving average (WMA) has the specific meaning of weights that decrease in arithmetically progression [2].

An exponential moving average (EMA), also known as an exponentially weighted moving average (EWMA), is a type of infinite impulse response filter that applies weighting factors which can decrease exponentially. The weighting for each older datum point decrease exponentially, never reaching zero. The graph at right shows an example of the weight decrease.

In the previous research, Hansun had introduced a new approach of moving average method which combine the WMA and EMA methods [3]. The authors combined the new approach from Hansun with optimization and use the result for rate of return. The proposed method will be implemented in
PT Adhi Karya (Persero) Thbk. stock closing data, taken daily from March 1st, 2017 to March 1st, 2018, and was compared with other moving average methods.

**Weighted Moving Average**

Weighted average means that the calculated value by giving values in a data set gives influence according to some attribute of the data. It is an average in which each quantity to be averaged is assigned a weight, and these weightings determine the relative importance of each quantity on the average. Weightings are the equivalent value of having similar items with the same value involved in the average [4]. The formula can be described in equation (1), where $n$ refers to the period or span number of forecasting formula and $P_{m}$ refers to the value of time series data at point $m$ [2].

$$WMAdn, m = \frac{nP_{m} + (n-1)P_{m-1} + \ldots + 2P_{m-n+2} + P_{(m-1)}}{n + (n-1) + \ldots + 2 + 1}$$

(1)

**Brown’s Double Exponential Smoothing**

Brown’s Double Exponential Smoothing and Brown’s Linear Exponential Smoothing was similar. The basic theory of Brown exponential is similar to the linear quadratic average method, when there is the trend single and double smoothing both lag the actual values. The difference between the values of the single and double smoothing is added to the single smoothing value, and it can correct the trend [5]. Thus, method has only one constant (alpha parameter) whose make a big impact for the forecasting result, so an optimum alpha parameter is required for accurate result. Therefore, the alpha parameter can be optimized by using Levenberg-Marquardt algorithm in R software. After that, the optimal alpha parameters are obtained, the next step is to forecast the process using a double exponential multiplication of one parameter adopted from Brown.

The formula’s based on an extrapolation from a line through the two centers and can be described as below [6]. Let $S$ denote the single-smoothed series obtained by applying simple exponential smoothing to series $Y$ and $S^*$ denote the double-smoothed series obtained by applying simple exponential smoothing (using the same constant smoothing factor, (a) to series $S$:

$$S^*_0 = x_0$$

$$S^*_0 = x_0$$

(2)

$$S^*_t = \alpha x_t + (1 - \alpha)S^*_{t-1}$$

(3)

Then, the forecast for $Y_{t+m}$, for any $m > 1$, is given by:

$$F_{t+m} = a_t + b_t m$$

(4)

where $a_t$ is the estimated level at time $t$, and $b_t$ is estimated trend at time $t$.

$$a_t = S^*_t + (S^*_t - S^*_0) = 2S^*_t - S^*_0$$

$$b_t = \frac{\alpha}{1 - \alpha} (S^*_t - S^*_0)$$

(5)

(6)

**Brown’s Weighted Exponential Moving Average**

A new approach is introduced by combining the calculation of weighting factors for Weighted Moving Average and Brown’s Double Exponential Smoothing. It is an improved version of Weighted Exponential Moving Average (WEMA) method which had been introduced in 2013 [7]. The proposed method called as Brown’s Weighted Exponential Moving Average (B-WEMA). B-WEMA that can uses to predict future values of time series data with a trend pattern.

Here is the algorithm’s procedure of B-WEMA method [3].

1. Calculate the base value $B^*$, Using equation (1) for given time series data and periods.
2. Using the base value obtained, calculate the prediction value by implementing equation (2)-(6), where

$$S^*_{t-1} = S^*_{t-1} = B_t$$

(7)

3. Back to step (1) until each data point in the time periods given ended.

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Mean Squared Error (MSE)
Mean Squared Error (MSE) is a method to evaluate a forecasting method. The error or residue is squared from the summed and divided with the number of observations. This approach makes the big forecasting error, because the errors are squared. This method produces errors that uses for reach a small errors, but sometimes can make a big difference. The formula can be written as equation [8],

\[
MSE = \frac{\sum_{i=1}^{n} e_i^2}{n} \tag{8}
\]

Mean Absolute Percentage Error (MAPE)
Mean Absolute Percentage Error (MAPE) gives indication about how much the average of absolute error of the forecasting data compare to the actual data. Then, averaging those fixed percentages, with the formula (9) [8],

\[
MAPE = \frac{\sum_{i=1}^{n} \left| \frac{e_i}{Y_i} \right|}{n} \times 100 \tag{9}
\]

Optimization
A value of \( \alpha = 1 \) implies that this period’s demand is next month’s forecast (or level estimate) – the so-called naïve forecasting method. A value of \( \alpha = 0 \) implies that the demand in a given period is irrelevant to the forecast for the next period: \( F_{t+1} = F_t \) for all \( t \). In other words, the initial forecast is the forecast for all subsequent periods. This can happen if the initial forecast is close to the average of the series. If the data has no trend, MSE is minimized if each forecast is close to the average of the data. This is achieved by making minimal changes to the initial forecast; i.e., making \( \alpha \) small or even 0. Larger values of \( \alpha \) will be necessary if the initial forecast is not comparable with the data. By favoring actual demand larger \( \alpha \) will bring future forecasts into line with the data. The same logic holds good with MAD [9].

Although it’s a good idea to determine the initial forecast also through optimization along with the smoothing constants, the deterioration in Solver’s solution times makes it impractical in a classroom setting. A better idea is use an initial forecast that close to the demand values of the initial periods or to estimates it through a technique such as regression. Regression can also used to determine starting values for trend. The extreme values of \( \alpha \) and \( \beta \) that resulted from optimization conflict with the recommendation of most introductory textbooks to keep smoothing constants small, no more than 0.50. The basis for this recommendation, theoretical or empirical, is not clear. Gardner (2006), reported that there is no evidence to support such a restricted range of parameters, it is risk to guess at values of the smoothing parameters [10]. The parameters should be estimated from the data. In any case, it cannot be assumed that the underlying demand generation process will stay the same in the future. It seems prudent to continuously monitor forecasts using MAD, MSE, MAPE, or some other measures of forecast error and use values of \( \alpha \) and \( \beta \) that keep these measures within acceptable limits.

Rate of Return
A rate of return is the gain or loss on an investment over a specified time period, it expressed a percentage of the investment’s cost. Gains on investment are defined as the income received plus any capital gain realizes on the sale of the investment. Rate of return can also be defined as the net amount of discounted. Cash flows received on an investment. A rate of return can be applied for any investment vehicle, from real estate to bonds, stocks and fine art, provided the asset that purchases the one point in time and produces cash flow at some point in the future. Investment are assessed based, in part, on past rates of return, that can be compared against assets of the same type to determine which investments are the most attractive [11]. Rate of return geometric is calculated using logarithm calculation from the stock price at time \( t \) then divided by previous stock price \((t-1)\). The formula can be described in equation (10), where \( R \) refers to the rate of return, \( P_t \) refers to the value of stock price at point \( t \) and \( P_{t-1} \) refers to the value of stock price at point \( t-1 \) [12].
\[ R = \log \left( \frac{P}{P_{t-1}} \right) \]  

(10)

**Results and Discussions**

In this chapter, a comparison of three methods and the graph for forecasted data based on rate of return. Before that, optimization was done for alpha parameters. The process for obtaining an optimal alpha value used Levenberg-Marquardt algorithm using R software. By entering alpha parameter values randomly, an alpha parameter value that optimal with that value 0.44517 was generated. The next step is to forecast the process using a double exponential multiplication of one optimal parameter adopted from Brown. The authors used 256 PT. Adhi Karya (Persero) Tbk. closing index data, taken daily from March 1\textsuperscript{st}, 2017 to March 1\textsuperscript{st}, 2018 [13].

Figure 1, Figure 2 and Figure 3 show the forecasting result using WMA, B-DES, and B-WEMA method. The real (actual) stock closing data are indicated by the blue line on graph, while the predicted data are indicated by the red line. From the graph, B-WEMA was better able to follow the actual data movement pattern compared to WMA and B-DES.

![Fig.1: Weighted Moving Average Forecasting Results](image1)

![Fig.2: Brown’s Double Exponential Smoothing Forecasting Results](image2)
Fig.3: Brown's Weighted Exponential Moving Average Forecasting Results

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<th>Method</th>
<th>MSE</th>
<th>MAPE</th>
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<tr>
<td>WMA</td>
<td>3188.938</td>
<td>1.9713%</td>
</tr>
<tr>
<td>B-DES</td>
<td>2620.318</td>
<td>1.7093%</td>
</tr>
<tr>
<td>B-WEMA</td>
<td>2100.488</td>
<td>1.4959%</td>
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The best result, should have the smallest MSE and MAPE. Based from Table 1, the smallest of MSE and MAPE are from B-WEMA method. It means that B-WEMA is the best method that can be used as a better forecasting tool in time series analysis. From the value of forecast B-WEMA, the author found out the value of rate of return.

Fig.4: Rate of Return Forecasting Results

Rate of return is the interest rate that an investor receives on an amortized investment. To calculate the upper rate of return, Return on investment returns that are not amortized. The author shows the graph of rate of return, the result rate of return from the forecast for next three periods of 0.660%, 0.254%, 0.254% with the average rate of return value of 0.809%. It means, during the investment year, investors get a profit of 0.0809% per day from the total funds invested in stock PT. Adhi Karya (Persero) Tbk.

Conclusions
In this paper, the authors combines the basic formula of Weighted Moving Average (WMA) to get a baseline value, and then use it to get the approximate value using Brown's Double Exponential Smoothing formula. The combination of two methods called Brown's Weighted Exponential Moving Average. Optimization of alpha parameters used to obtain the best parameters used software R with Levenberg-Marquardt algorithm yields an optimization value of alpha parameter of 0.445175.
The experiment results on 256 PT.Adhi Karya (ADHIJK) index data, taken daily from March 1st, 2017 to March 1st, 2018, composite index data shows a promising result. By comparing Weighted Moving Average, Brown’s Double Exponential Smoothing and Brown’s Weighted Exponential Moving Average resulted that Brown’s Weighted Exponential Moving Average is the best method, because it has the smallest MSE and MAPE value that uses for forecast the rate of return that yields a value of 0.0082%, -0.0138%, -0.0138% with the average rate of return value of 0.0226%. It means, during the investment year, investors get a profit of 0.0226% per day from the total funds invested in stock PT.Adhi Karya (Persero) Tbk.

References
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