Comparison of Double Exponential Smoothing Model and Auto Regressive Integrated Moving Average Model for Financial Data

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ABSTRACT
Stock market volatility is important for investment, option pricing and financial market regulation. In recent years, stock market analysis and prediction have the greatest significance for many professionals in the fields of finance and stock exchange. There are many methods available in the literature to solve the problem of future prediction. The present study provides a detailed comparison of Double Exponential Smoothing (DES) model and Auto Regressive Integrated Moving Average (ARIMA) model. Future values are forecasting using DES and ARIMA model. Forecasted values for different $\alpha$ and $\beta$ values are calculated from DES method and ARIMA (1, 1, 1). Also, Mean Square Error (MSE), Root Mean Square (RMSE), Mean Absolute Deviation (MAD) and Mean Absolute Percentage Error (MAPE) are calculated individually for both methods.

Keywords: Time Series, Double Exponential Smoothing, ARIMA and Forecasting.

I. INTRODUCTION

Financial analysis and forecasting have a great significance for many professionals in the fields of finance and the stock market. An important part of the analysis of a time series is the selection of a suitable probability model for the data. Time series analysis and its applications have become more essential in various fields of research, such as business, economics, engineering, medicine, social sciences and politics. This analysis can be used to carry out different goals such as descriptive analysis, spectral analysis, forecasting, intervention analysis and explanatory analysis.

One of the most successful forecasting methods is the exponential smoothing methods. Moreover, it can be modified efficiently to use effectively for time series with seasonal patterns. It is also easy to adjust for past errors easy to prepare to follow on forecasts; several different forms are used depending on the presence of trend or cyclical variations. In short, an exponential smoothing method is an averaging technique that uses unequal weights; however, the weights are applied to past observations decline in an exponential manner.

The construction of forecast function based on discounted past observations is most commonly carried out by exponential procedures. These procedures are attractive, that they allow the forecast function to be updated very easily every time a new observation become popular since they are easy to implement and can be quite effective, they are implemented without respect to a properly defined statistical models.

II. LITERATURE SURVEY

We discussed here, various forecasting methods based on DES and ARIMA. Hansun (2016) has introduced a new approach of Brown’s Double Exponential Smoothing in time series analysis. The new approach will combine the calculation of
weighting factor in Weighted Moving Average and implement the results with Brown’s Double Exponential Smoothing method. The proposed method will be tested on Jakarta Stock Exchange (JKSE) composite index data.

Seng Hansun and Subanar (2016) have introduced a new approach of double exponential smoothing, called H-WEMA, which combines the calculation of weighting factor in weighted moving average with Holt’s double exponential smoothing method. The proposed method will then be tested on Jakarta Stock Exchange (JKSE) composite index data. The accuracy and robustness level of the proposed method will then be examined by using mean square error and mean absolute percentage error criteria, and be compared to other conventional methods.

Prapanna Mondal et al., (2009) have conducted a study on the effectiveness of Autoregressive Integrated Moving Average (ARIMA) model, on fifty six Indian stocks from different sectors. We have chosen ARIMA model, because of its simplicity and wide acceptability of the model. We also have studied the effect on prediction accuracy based on various possible previous period data taken. The comparison and parameterization of the ARIMA model have been done using Akaike information criterion (AIC).

III. MATERIALS AND METHODS

3.1 Data Source

The data on daily closing Prices for Nifty Financial Services (NIFTYFIN) have been collected from the web sites www.investing.com for the period from 1st April, 2015 to 31st May, 2018.

3.2 Exponential Smoothing Method

Time series data occur frequently in many real world applications. One of the major important steps in analyzing a time series data is the selection of appropriate statistical model for the data. Because it helps in prediction, hypothesis testing and rule discovery.

One of the most efficient and successful forecasting methods is the exponential smoothing techniques. Also, it can be changed efficiently to use effectively for time series with seasonal patterns. It is also easy to adjust for past errors and easy to prepare to follow on forecasts, ideal for situations where many forecasts must be prepared, several different ways of forms are used depending on the presence of trend or cyclical variations. In other words, an exponential smoothing is an averaging technique that uses unequal intervals; however, the intervals applied to past observations decline in an exponential manner. An exponential smoothing over an already smoothed time series is called double exponential smoothing. In some other cases, it might be necessary to extend it even to a triple exponential smoothing.
An exponential smoothing over an already smoothed time series is called double exponential smoothing. In some other cases, it is necessary to extend it up to a triple-exponential smoothing. While SES requires stationary conditions, the double exponential smoothing can evaluate in linear trends and triple exponential smoothing can handle both trend and seasonal pattern in time series data. Figure 1 shows the selection procedure of different exponential smoothing method is defined.

3.2.1 Double Exponential Smoothing

If time series contains linear trend with linear regression equation $\hat{x}_t = a + bt$ where the estimates $a$ and $b$ represent the intercept and slope of the model and $t = 1, 2, 3, \ldots n$, the correct procedure would be Double exponential smoothing. The argument and techniques for the double exponential smoothing method are similar in nature to that of single exponential smoothing. A form of smoothing equation:

Next period forecast = weight * (present period observation) + $1 - \text{weight}$ * present period forecast

If we let

$$\hat{x}_t = a + b_t (T)$$
Represent the updated forecast, then
\begin{align*}
    a_t &= 2S_{t}^{(1)} - S_{t}^{(2)} \quad \text{(updated intercept)} \quad (1) \\
    b_t &= \frac{\alpha}{1-\alpha} \left( S_{t}^{(1)} - S_{t}^{(2)} \right) \quad \text{(Updated slope)} \quad (2)
\end{align*}

T = number of the time period ahead. The \( S_{t}^{(1)} \) and \( S_{t}^{(2)} \) are the single and double smoothing statistics found by applying the smoothing equation
\begin{align*}
    S_{t}^{(1)} &= \alpha x_t + (1-\alpha)S_{t-1}^{(1)} \quad (3) \\
    S_{t}^{(2)} &= \alpha S_{t}^{(1)} + (1-\alpha)S_{t-1}^{(2)} \quad (4)
\end{align*}

Once the single and double smoothed statistics are computed for a time period, the values may be substituted into the updating formula for the intercept and slope. To start the double smoothing process, initial values of the smoothed estimates must be obtained; this can be done by substituting the values for the estimated intercept and the slope from the linear regression analysis into the following equations
\begin{align*}
    S_0 &= a - \left[ \frac{1-\alpha}{\alpha} \right] (b) \quad (5) \\
    S_0^{(2)} &= a - 2 \left[ \frac{1-\alpha}{\alpha} \right] (b) \quad (6)
\end{align*}

### 3.3 ARIMA Model

ARIMA Model was introduced by Box Jenkins in 1976 and they recommend differencing non-stationary series one or more times to obtain stationary. The term integrated is used because the differencing process can be reversed to obtain the original series. When the explanatory variables in a regression model are time-lagged values of the forecast variable, then the model is called an autoregressive (AR) model. The general form of an autoregressive model of order \( p \) denoted as AR (p), is
\begin{align*}
    Y_t &= b_0 + b_1 Y_{t-1} + b_2 Y_{t-2} + \cdots + b_p Y_{t-p} + e_t \quad (7)
\end{align*}

where \( e_t \) is the error or residual term and \( p \) is an integer denoting the order of the in which the observations in the time series are correlated.

When a time series is analyzed using its dependence relation with the past error terms, a moving average (MA) model is applied. The general form of the MA(q) model of order \( q \) is
\begin{align*}
    Y_t &= \varphi_0 + \varphi_1 e_{t-1} + \varphi_2 e_{t-2} + \cdots + \varphi_q e_{t-q} + e_t \quad (8)
\end{align*}

Autoregressive (AR) model can be effective coupled with moving average (MA) model to form a general and useful class of time series models called autoregressive moving average ARMA (p, q) models. However, they can only be used when the time series is stationary. When a time series is studied based on the dependence relationship among the time lagged values of the forecast variable and the past error terms, an autoregressive integrated moving average (ARIMA) model is more appropriate. It can be used when the time series is non-stationary. The general form of the ARIMA (p, d, q) model is
\[ Y_t = b_0 + b_1 Y_{t-1} + b_2 Y_{t-2} + \cdots + b_p Y_{t-p} + \varphi_1 e_{t-1} + \varphi_2 e_{t-2} + \cdots + \varphi_q e_{t-q} + e_t \]  
\hspace{1cm} \text{(9)}

where p, d and q represent respectively the order of an autoregressive part, the degree of differencing involved in the stationary time series which is usually 0, 1 or at most 2 and the order of the moving average part.

An ARIMA model can be obtained by estimating its parameters. The values of p and q can be determined from the patterns in the plotting of the values of ACF and PACF. The spikes falling above the time axis are used to estimate the value of p. the spikes falling below the time axis are used to estimate the value of q. For an AR (p) model, the spikes of ACF decay exponentially or there is a sine wave pattern and the spikes of PACF are close to zero beyond the time lag q whereas the spikes of PACF decay exponentially or there is a sine wave pattern.

IV. RESULTS AND DISCUSSIONS

For the selected data has trend and no seasonality so we should have to use DES method. Forecasted values were obtained for different \( \alpha \) & \( \beta \) values (0 to 1). When \( \alpha =0.9 \) and \( \beta =0.1 \) forecasted values is much closer to the actual values compare with the other \( \alpha \) and \( \beta \) values. The maximum difference of actual and forecasted value is Rs. 481.663 for 24th August 2015 and percentage of error is 0.07.

For the selected data values has possessed the ARIMA (1, 1, 1) Model. Actual values do not possess the stationary conditions so First order difference is calculated and it satisfies the stationary, so we have used d=1. Then the combination of p, d and q values (without changing the d=1) have found the different BIC values. Among the BIC values ARIMA (1, 1, 1) having the minimum value (8.89). Based on ARIMA (1, 1, 1) values are forecasted. The maximum difference of actual and forecasted value is Rs. 463.297 for 24th August 2015 and Percentage of error is 0.067.

We compare the forecasted values of DES and ARIMA (1, 1, 1), the ARIMA (1, 1, 1) values are very closer to actual values.
Figure 2 Comparison of Observed and Estimated Value of NIFTYFIN Price

Figure 2 shows the line chart of actual and forecasted values, which shows that actual values are closely associated with the ARIMA (1, 1, 1) model. The following Table 1 shows, MSE, MAPE, MAD and RMSE.

Table 1
Forecasted Error Values

<table>
<thead>
<tr>
<th>Errors</th>
<th>DES</th>
<th>ARIMA(1,1,1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSE</td>
<td>7568.339</td>
<td>7327.869</td>
</tr>
<tr>
<td>MAPE</td>
<td>0.81%</td>
<td>0.79%</td>
</tr>
<tr>
<td>MAD</td>
<td>65.08722</td>
<td>64.10596</td>
</tr>
<tr>
<td>RMSE</td>
<td>86.9962</td>
<td>85.60297</td>
</tr>
</tbody>
</table>

V. CONCLUSIONS

Forecasting of Nifty Financial Service price prediction is a very tedious job. Over the years, a lot of forecasting techniques have tried and used for forecasting. In this paper forecasted Nifty Financial Service price using DES and ARIMA (1, 1, 1). DES is very flexible to use the non-linear model. Because we can adjust the values of Α and β, from which we can reduce the error values. The ARIMA models present some difficulties in estimating and validating the model. The error values such as MSE, RMSE, MAD and MAPE are compared for two models. In this case, ARIMA (1, 1, 1) model error values are less than the DES model. It concludes that ARIMA (1, 1, 1) model is more appropriate for Nifty Financial Service price prediction.

REFERENCES
