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CONTENTS

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   RESEARCH METHODOLOGY

   RESULTS & DISCUSSION

   FINDINGS

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CONTRIBUTIONS TO BOOKS

- Sharma T., Kwatra, G. (2008) Effectiveness of Social Advertising: A Study of Selected Campaigns, Corporate Social Responsibility, Edited by David Crowther & Nicholas Capaldi, Ashgate Research Companion to Corporate Social Responsibility, Chapter 15, pp 287-303.

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CRYTICAL ANALYSIS OF EXPONENTIAL SMOOTHING METHODS FOR FORECASTING

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ABSTRACT

Financial forecasting is important for an organization; it enables management to change operations at the right time in order to reap the greatest benefit. It also helps the company prevent losses by making the proper decisions based on relevant information. Organizations that can create high quality and accurate forecasts are able to see what interventions are required to meet their business performance targets. Forecasting is also important when it comes to developing new products or new product lines. It helps management decide whether the product or product line will be successful. Forecasting prevents the company from spending time and money developing, manufacturing, and marketing a product that will fail. The selection and implementation of the proper forecast methodology has always been an important planning and control issue for most firms and agencies. Often, the financial wellbeing of the entire organization operation rely on the accuracy of the forecast, since such information will likely be used to make interrelated budgetary and operative decisions in areas of personnel management, purchasing, marketing and advertising, capital financing, etc. The present article mainly focus on Single exponential smoothing method of Time Series analysis for forecasting, How trend and seasonality factor influences the Time Series data in forecasting, How these factor smoothed by double exponential smoothing, triple exponential smoothing methods and also discuss the impact of the smoothing constants (α) on forecasting.

KEYWORD

Forecasting, Exponential Smoothing, Time Series Analysis, Trend Factor, Seasonality.

INTRODUCTION

Accurate forecasting is vital in many areas of scientific, industrial, commercial and economical activities. The selection and implementation of the proper forecast methodology has always been an important planning and control issue for most firms and agencies. Often, the financial wellbeing of the entire organization operation rely on the accuracy of the forecast, since such information will likely be used to make interrelated budgetary and operative decisions in areas of personnel management, purchasing, marketing and advertising, capital financing, etc[1][5].

For Example any significant over-or-under sales forecast error may cause the firm to be overly burdened with excess inventory carrying costs or else create lost sales revenue through unanticipated item stock outs. When demand is fairly stable (e.g., unchanging or else growing or declining at a known constant rate), making an accurate forecast is less difficult on the other hand if the firm has historically experienced an up-and-down sales pattern, then the complexity of the forecasting task is compounded.

There are two main approaches to forecasting. The estimation of future value is either based on an analysis of factors which are believed to influence future values (the explanatory method) or the prediction is based on an inferred study of past general data behavior over the period of time (the extrapolation method) [2].

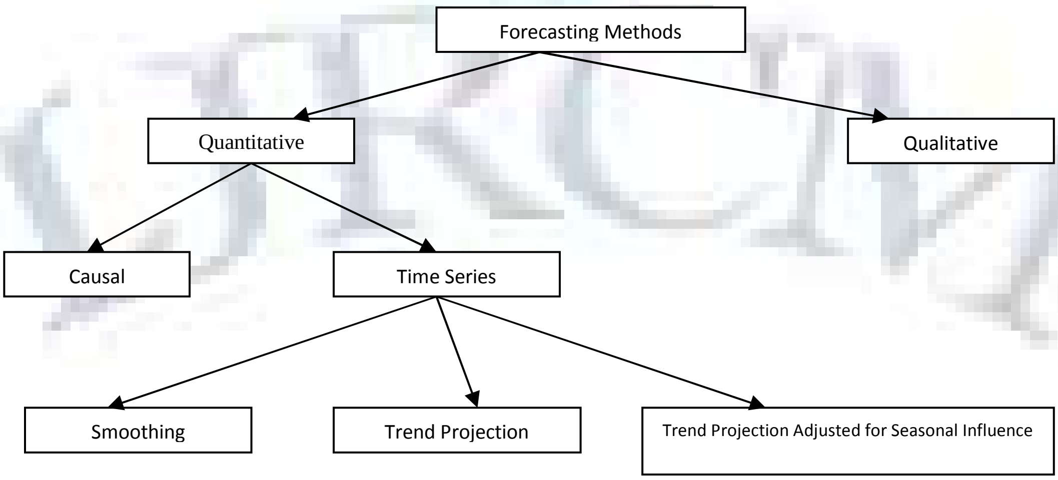
For example, the sale of branded textile outlet will increase from current levels because of a recent advertising blitz rather than proximity to Christmas illustrates the difference between the two philosophies. It is possible that both approaches will lead to the creation of accurate and useful forecasts, but for a modest degree of desired accuracy the former method is often more difficult to implement and validate than the latter approach.

FORECASTING METHODS

Broadly the forecasting can be categorized into the Qualitative Forecasting and Quantitative Forecasting. Qualitative Methods of forecasting are subjective in nature and rely on human judgment and opinion. This method is used when situation is vague & few values of past data are available. Qualitative Methods basically used in forecasting of new products and technology and heavily dependent upon intuition and experience of management. On the other hand Quantitative Methods uses mathematical or simulation models based on historical demand or relationships between variables. This method is used when situation is 'stable' & historical data over a period of time is available. Qualitative Methods is basically used in forecasting of existing products and current technology [2] [3].

This article is mainly concerned with forecasting using exponential smoothing methods, where forecasts are made on the basis of data comprising one or more time series.

FIG 1: FORECASTING METHODS



A *time-series* forecasting is based on collection of observations made sequentially through time with equal intervals, (i) sales of a particular product in successive months, (ii) the temperature at a particular location at noon on successive days, and (iii) electricity consumption in a particular area for successive one-hour periods, are few example of time series data.

There are various applications of time-series forecasting few of then are:

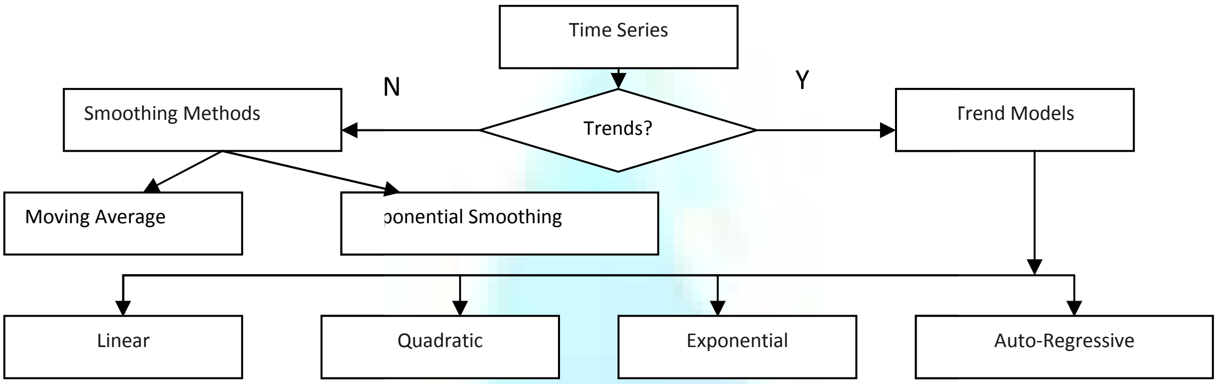
1. Economic planning

2. Sales forecasting
3. Inventory (or stock) control
4. Production and capacity planning
5. The evaluation of alternative economic strategies
6. Budgeting
7. Financial risk management
8. Model evaluation

TIME-SERIES FORECASTING MODELS

Time-series models are based on a series of discrete and equal time increments i.e. predictions for the next {week, month, quarter, year} are based on, and only on, the past values of the last N periods{weeks, months, quarter, years} of the variable [7].

FIGURE 2: TIME SERIES FORECASTING



A time-series has four main components that need to taken into account while forecasting [6] [7].

- **Trends**: A time series may be stationary or exhibit trend over time. Long-term trend is typically modeled as a linear, quadratic or exponential function
- **Seasonality:** Seasonalities are regular fluctuations which are repeated from year to year with about the same timing and level of intensity.
- **Cycles:** The fluctuations in a variable that occur repeatedly and in the long-term (i.e. every several years).
- **Random Variations***:* The irregular component is caused by short-term, unanticipated and non-recurring factors that affect the values of the time series. This component is the residual, or "catch-all," factor that accounts for unexpected data values. Random variation is often unpredictable**.**

EXPONENTIAL SMOOTHING OVERVIEW

When the time series data is fairly stable and has no significant trend, seasonal, or cyclical effects, smoothing methods is able to average out the irregular component. Exponential smoothing (ES) is one of the most successful methods for forecasting, simple moving average (MA) method is a special case of the exponential smoothing (ES).Exponential smoothing (ES) is more parsimonious in its data usage and can be modified efficiently to use effectively for time series data having trend and seasonal patterns. Different categories of Exponential smoothing (ES) can easily adjust past errors, easy to prepare follow-on forecasts, and ideal for situations where many forecasts must be prepared depending on presence of trend or cyclical variations of time series data. In short, an exponential smoothing (ES) is an averaging technique that uses unequal weights, however, the weights applied to past observations decline in an exponential manner[3][4].

There are some categories of this method:

1. Single exponential smoothing
2. Browns Double exponential smoothing method
3. Holts Double exponential smoothing method
4. Winters Triple exponential smoothing method

SINGLE EXPONENTIAL SMOOTHING

Single Exponential Smoothing is a procedure that repeats enumeration continually by using the newest data. This method can be used if the data is not significantly influenced by trend and seasonal factor.

To smooth the data with single exponential smoothing requires a parameter called the smoothing constant (α). Each data point is given a certain weighting, α for the newest data, (1- α) for older data and etc. The value of α must be between 0 and 1. The following is the equation of smoothed value [9]:

$$S_n = \alpha[Y_n + (1-\alpha)Y_{n-1} + (1-\alpha)^2 Y_{n-2} + \ldots]$$

By doing a simple substitution, the equation above can be written as:

$$S_n = \alpha Y_n + (1-\alpha)S_{n-1}$$ (S_i-smoothed value and Y_i-actual value)

Forecasting value $\hat{Y}_{n+1}$

Forecasting with single exponential smoothing can be done by substituting this equation:

$$\hat{Y}_{n+1} = \alpha Y_n + (1-\alpha)\hat{Y}_n$$

The equation above also can be written in the following way:

$$\hat{Y}_{n-1} = \hat{Y}_n + \alpha(e_n)$$

Where $e_n = (Y_n - \hat{Y}_n)$ is the forecasting error for n period. From this equation, we can see that the forecasting resulted with this method is the last forecasted value added with an adjustment for error in the last forecasted value.

Starting value S_0

Practically, to calculate the smoothing statistic at the first observation Y_1, we can use the equation $S_1 = \alpha Y_1 + (1-\alpha)S_0$. Then it is substituted into the smoothing statistic equation to calculate $S_2 = \alpha Y_2 + (1-\alpha)S_1$, and the smoothing process is continued until we get S_n value. To calculate the equation above, a starting value S_0 is needed. S_0 can be calculated from the average of several observations. The first several observations can be chosen to determine S_0.

IMPACT OF THE SMOOTHING CONSTANTS (ALPHA)

The smoothing constants values lies in the range of 0.0-1.0, the "best" values to use for the smoothing constants is depends on how data series being modeled for forecasting

In general, the speed at which the older responses are dampened (smoothed) is a function of the value of the smoothing constant. When this smoothing constant is close to 1.0, dampening is quick - more weight is given to recent observations - and when it is close to 0.0, dampening is slow - and relatively less weight is given to recent observations. For example if alpha value is .7 it means that 70% of the next forecast will come from the most recent observation and only 30% will come from all the previous forecasts. The best value for the smoothing constant is the one that results in the smallest mean of the squared errors (or other similar accuracy indicator).

DOUBLE EXPONENTIAL SMOOTHING (BROWNS)

This smoothing method can be used for data which contains linear trend. This method is often called as Brown's one-parameter linear method. The following equations are used in double exponential smoothing with Browns method:

Single smoothing statistic equation:

$$S'_n = \alpha Y_n + (1-\alpha)S'_{n-1}$$

Double smoothing statistic equation:

$$S''_n = \alpha S'_n + (1-\alpha)S''_{n-1}$$

Forecasting value $\hat{Y}_{n+m}$

The procedure to calculate forecasting m forward period with double exponential smoothing with Brown method can be calculated from this equation:

$$\hat{Y}_{n+m} = \beta_{0,n} + \beta_{1,n}m$$

This equation is similar to linear trend method, where:

$$\beta_{0,n} = 2S'_n - S''_n$$

$$\beta_{1,n} = \frac{\alpha}{1-\alpha}\left(S'_n - S''_n\right)$$

Starting value S_0

The smoothing statistic equation above can be solved if the estimation value for S_0 is defined. Starting value S_0 is defined as:

$$S'_0 = \hat{\beta}_{0,0} - \frac{\alpha}{1-\alpha}\hat{\beta}_{1,0}$$

$$S''_0 = \hat{\beta}_{0,0} - 2\frac{\alpha}{1-\alpha}\hat{\beta}_{1,0}$$

We can use linear trend model constant calculated with the least squares estimation method to estimate the coefficient of S_0, $\hat{\beta}_{0,0}$ and $\hat{\beta}_{1,0}$.

DOUBLE EXPONENTIAL SMOOTHING (HOLTS)

This method is similar to Browns method, but Holts Method uses different parameters than the one used in original series to smooth the trend value.

The prediction of exponential smoothing can be obtained by using two smoothing constants (with values between 0 and 1) and three equations as follows:

$$S_n = \alpha Y_n + (1-\alpha)(S_{n-1} + T_{n-1}) \quad (1)$$

$$T_n = \gamma(S_n - S_{n-1}) + (1-\gamma)T_{n-1} \quad (2)$$

$$\hat{Y}_{n+m} = S_n + T_n m \quad (3)$$

Equation (1) calculates smoothing value S_n from the trend of the previous period T_{n-1} added by the last smoothing value S_{n-1}. Equation (2) calculates trend value T_n from S_n, S_{n-1}, and T_{n-1}. Finally, equation (3) (forward prediction) is obtained from trend, T_n, multiplied with the amount of next period forecasted, m, and added to basic value S_n.

The first smoothing equation adjusts S_n directly for the trend of the previous period, T_{n-1} by adding it to the last smoothed value, S_{n-1}. This helps to eliminate the lag and brings S_n to the appropriate base of the current value.

The second smoothing equation then updates the trend, which is expressed as the difference between the last two values. The equation is similar to the basic form of single smoothing, but here applied to the updating of the trend

Starting value S_0 **and** T_0

There are two parameters needed to estimate exponential smoothing with Holts method, the smoothing value S_0 and the trend T_0. To find these parameters, the least squares method is used. The estimation value for S_0 is the intercept value of linear estimation, while T_0 is the slope value.
S_0 is in general set to y_1. Here are three suggestions for T_0:
$T_0 = y_2 - y_1$
$T_0 = [(y_2 - y_1) + (y_3 - y_2) + (y_4 - y_3)]/3$
$T_0 = (y_n - y_1)/ (n - 1)$
The values for α and γ can be obtained via non-linear optimization techniques, such as the Marquardt Algorithm

TRIPLE EXPONENTIAL SMOOTHING (WINTERS)

If a time series is stationary, the moving average method or single exponential smoothing can be used to analyze it. If a time series data has a trend component, then double exponential smoothing with Holts method can be used. However, if the time series data contains a seasonal component, then the Triple Exponential Smoothing (Winters) method can be used to handle it.
This method is based on three smoothing equations, Stationary Component, Trend and Seasonal. Both Seasonal component and Trend can be additive or multiplicative.

Additive

The whole smoothing equation

$$\mu_n = \alpha(y_n - S_{n-l}) + (1-\alpha)(\mu_{n-1} + T_n)$$

Trend smoothing

$$T_n = \gamma(\mu_n - \mu_{n-1}) + (1-\gamma)T_{n-1}$$

Seasonal smoothing

$$S_n = \beta(Y_n - \mu_n) + (1-\beta)S_{n-l}$$

Forecasted value

$$\hat{Y}_{n+m} = \mu_n + T_n m + S_{n-l+m}$$

Multiplicative

The whole smoothing equation

$$\mu_n = \alpha\frac{y_n}{S_{n-l}} + (1-\alpha)(\mu_{n-1} + T_n)$$

Trend smoothing

$$T_n = \gamma(\mu_n - \mu_{n-1}) + (1-\gamma)T_{n-1}$$

Seasonal smoothing

$$S_n - \beta\frac{Y_n}{\mu_n} + (1-\beta)S_{n-l}$$

Forecasted value

$$\hat{Y}_{n+m} = (\mu_n + T_n m)S_{n-l+m}$$

Where l is seasonal length (for example, amount of month, or quartile in a year), T is trend component, S is seasonal adjustment factor, and $\hat{Y}_{n+m}$ is forecasted value for m next period.

Starting value μ_0, T_0 and S_{j-l}

The starting values for μ_0 and T_0 can be obtained from regression equations which have actual variables as dependent variables and time variables as independent variables. This equation constant is a starting value estimation for μ_0 and slope of regression coefficient is starting value estimation for the trend component T_0. Whereas the starting value for the seasonal component S_{j-l} is calculated by using dummy-variable regression on de trended data (without trend).

CONCLUSION

Moving average methods of forecasting has got certain limitation like i) Increasing N (no of instance of time series) makes forecast less sensitive to changes ii) Do not forecast trends and seasonal smoothing well iii) Forecasting require sufficient historical data. Exponential smoothening methods taken care of the limitation of moving average and can be utilize for the developing the mathematical model for forecasting. Single Exponential Smoothing is used in a situation in which the data is not significantly influenced by trend and seasonal factor. Double Exponential Smoothing is used for data which contains linear trend but no seasonality and Triple Exponential Smoothing (Winters) can be used if the time series data contains a seasonal component also.

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