Usage of Holt's Linear Trend Exponential Smoothing for Time Series Forecasting in Agricultural Research

Amit Saha[1] and Kanchan Sinha[2]

[1]Scientist, CSRTI-Mysore, Central Silk Board, Ministry of Textiles, Government of India [2]Scientist, ICAR- Indian Agricultural Statistics Research InstituteEmail: amitsahauni@gmail.com

ABSTRACT

Exponential smoothing is one of the frequently used forecasting techniques in several areas, since its inception. Among various types of smoothing methods, Holt's linear trend exponential smoothing method is a renowned method in the gamut of time series forecasting which is useful in several areas of agricultural forecasting with trend data. This article depicts a brief description of Holt's Linear trend exponential smoothing method for forecasting time series data displaying trend.
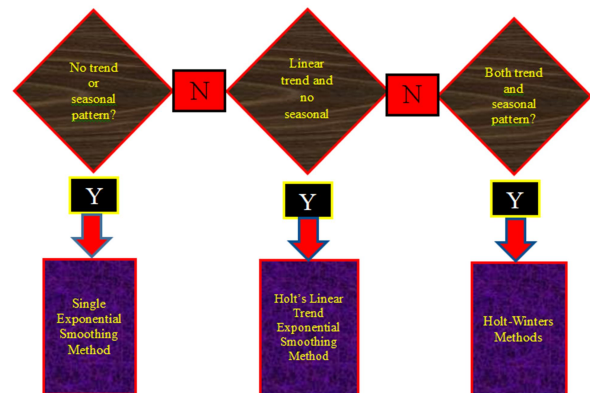
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Time series data analysis means analysis of time series data to get the meaningful information from the data. Time series forecasting uses model to predict future values based on previous observed values at the present time. Exponential smoothing is one of the most preferred methods for a wide variety of time series data in agricultural areas for its simplicity to understand, easy to implement with a simple numerical program, and for reliable forecast in a wide variety of applications. In addition, data storage and computing requirements for exponential smoothing are very minimal, which makes its usefulness in diverse application areas viz., environmental and biological sciences, ecology, tourism, business and finance, telecommunication and traffic engineering.

Exponential Smoothing methods

The weighted moving average is an extension of the moving average method. Mean of the past n observations is taken to forecast using simple moving average. Therefore, equal weights are given to all the n observations. But, the most recent observations are very much significant as it provides the best guide for the future. So, there is a need for weighing scheme in which weights are decreasing as the observations get older. Many different class of methods are available in which observations are exponentially decreasing as the observations get older. These methods are known as exponential methods. The target is to determine one or more smoothing constants to give proper weightage to the observations. The exponential smoothing is

classified into three methods based on trend and seasonal components of the time series data which is depicted in the following figure.

Figure 1: Situation for using different types of exponential smoothing

Holt's Linear Trend method:

Single exponential smoothing (SES) is a well-known method of forecasting for stationary time series data. However, it does not provide superior result in the context of non-stationary time series data. Agricultural production data have a general tendency of increasing over the time. So, they contain a trend. Trend may be upward or downward. Downward trend will be found in mortality rate, literacy rate, epidemics etc. On the other hand, upward trend will be seen in data containing agricultural production, population etc. So, SES will not

be useful in such cases. Therefore, Holt gave a method to deal with data pertaining trend which is known as Holt's linear trend method. Holt's linear trend method comprises two smoothing constants, two smoothing equations and one forecast equation. It has total 3 equations.

$$\hat{y}_{t+k} = a_t + kc_t \tag{1}$$

$$a_t = \gamma y_t + (1-\gamma)(a_{t-1} + c_{t-1}) \tag{2}$$

$$c_t = \delta(a_t - a_{t-1}) + (1-\delta)c_{t-1} \tag{3}$$

whereas,

Eq. 1 represents the forecast equation
Eq. 2 denotes the level equation
Eq. 3 denotes the trend equation.
γ and δ are smoothing constants for level and trend respectively whose values lie on the interval between 0 to 1,
a_t and c_t represents estimate of the level and trend of time series respectively,
y_t denotes the observation at time t.
Eq. (1) shows that k step ahead forecast is equal to the previous estimated level plus k times previous estimated trend.
To do work with Holt's linear trend method, one has to initialize the process. One can take first observed value for the $L_1\ and\ (y_2 - y_1)$ value for b_1. In long run; it does not affect significantly to the forecasting accuracy. Combination of two constants which gives Lower MSE is to be selected.
Drawback of Holt's Linear Trend method:

The drawbacks of Holt's Linear Trend method are mentioned below:

1. Holt's exponential smoothing method shows good forecasting performance in the absence of seasonal or cyclical variations. In other words, it does not work with the data which show the seasonal or cyclical pattern.
2. It is better to use for short term forecasting as it is based on the assumption that future trend will follow the current trend.
3. It does not provide good result in case of small data.

Applications

Holt's linear method is useful in agricultural production forecasting, forecasting for export of cash crops like tea, coffee, cotton etc. Details of some applications are provided in the following table:

Table 1: Applications of Holt's Linear Trend Exponential Smoothing models in agriculture

Year	Title	Authors	Findings
2013	Comparison of statistical models for analyzing wheat yield time series	Michel and Makowski	They used eight statistical models to forecast wheat yield at the national and regional scales. Holt's exponential smoothing models showed its' better performance as compared to others.
2014	Comparison Of Forecasting Ability Of Different Statistical Models For Productivity Of Rice (Oryza Sativa L.) In India	Kumari *et al*.	They used various exponential smoothing models to forecast rice productivity. It was seen that Holt's linear trend model outperformed the other exponential smoothing models.
2015	Forecasting of Tea Export From India - An Exponential Smoothing Techniques Approach	Padmanaban K. *et al*.	Holt's linear trend exponential smoothing model was used to forecast the export of tea from India up to year 2020.
2015	Forecasting Major Vegetable Crops Productions in Tunisia	Khayati, A.	Holt's model was the best model to predict the productivity of potatoes, artichoke and pepper.
2018	Comparison of Exponential Smoothing Models for Forecasting Cassava Production	Oni and Akanle	The Holt's linear Trend method was found to have best described the data having the lowest error.

Conclusion

Time series forecasting is an important part of forecasting area in agriculture. Time series data are the data which are taken in an equal time sequence. In time series forecasting, single exponential smoothing (SES) is an eminent method of forecasting to deal with the time series data having no trend and no seasonal pattern. In reality, most of the data in agriculture shows the trend pattern over the time. So, these data generally contain trend. In this scenario, Holt's linear trend method can be useful to deal with the trend data. This method is very much useful in agricultural modeling and forecasting especially when the data display the trend pattern.

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