Forecasting of resin yield and number of blazes of naturally regenerated chir pine (*Pinus roxburghii* Sargent) in Himachal Pradesh by using single exponential smoothing method

Abstract

The present investigation entitled "Forecasting of resin yield and number of blazes of naturally regenerated chir pine (*Pinus roxburghii* Sargent) in Himachal Pradesh by using single exponential smoothing method" was carried out during the year 2020-2022. The secondary information was collected regarding the resin yield and number of resin blazes w.e.f. 2005 to 2022 from Himachal Pradesh State Forest Department. Exponential smoothing is a particular moving average technique applied to time series data and to produce smoothed data to make forecast. In exponential smoothing, one or more smoothing parameters are to be determined explicitly and those choices determine the weights assigned to the observations. Forecasting with the help of various linear and non-linear models is on the assumption that the series is stationary. Often time series is found to be non-stationary which means they are integrated and can be made stationary by differencing the time series. To check the stationarity of the number of blazes and resin yield, Augmented Dickey Fuller test was used. The results indicated that data was not approaching stationarity even after taking third difference. So, the prerequisite condition of ARIMA model is that the data should be stationary and if the time series data does not contain trend and seasonal components, Single Exponential Smoothing model was used. The Single Exponential Smoothing model was found to be best fit for the prediction of number of blazes and resin yield as per the high value of R^2, low value of MAPE and Normalized BIC.

Keywords: *Chir pine, Augmented Dickey Fuller test, Single Exponential Smoothing model*

Introduction

Out of the pines occurring naturally in India, viz., *Pinus bhutanica* Grieson, Long and Page, *Pinus merkusii* Jung and De Vr., *Pinus roxburghii* Sargent, *Pinus wallichiana* Jackson, *Pinus geradiana* Wall ex Lamb., and *Pinus Kesia* Royle ex Gord (Sahni, 1990), only *Pinus roxburghii* Sargent (*Pinus longifolia* Roxb.) is tapped commercially for resin as it yields about 3 to 6 kg per tree annually. The tapping is done on the trees having a diameter of 30 cm and above D.B.H. cm trees below this diameter are left untapped (Joshi, 1972). Its bark is red-brown in colour and grows thick, deeply and longitudinally fissured andit reaches up to height of 55 m and over 100 cm diameter at breast height[4-7]. Resins are complex oxidation products of various essential oils and vary in their chemical composition. They originate through the reduction and polymerization of carbohydrates, generally occurring as starch derivatives. They are insoluble in water but soluble in alcohol. They are inflammable and burn with smoke flame upon drying. Resins generally remain thick and viscous or sometimes change into a solid form.

Resins are classified into three classes:

I. True or hard resins: They are solid, brittle, more or less transparent, colourless, and odourless exudations. They are the best source of varnishes and generally lack essential oils e.g. Copals and Dammar.

II. Gum Resins: They are a mixture of both gums and resins and possess the properties of both groups. They contain traces of essential oils and are usually derived from plants growing in dry regions.

III. Oleoresins: They are liquids with a considerable amount of essential oil and resinous material. They possess a distinct aroma. The group of oleoresin includes turpentine, balsams, and elemis.

Resinous secretions occur in special cavities or passages in wide varieties of plants. Resins originate through the reduction and polymerization of carbohydrates. They may also represent oxidation products of various essential oils. As a scientific practice, trees are tapped for three years and then allowed to rest for three years consecutively. The tapings are done on the trees with diameters of 30 cm and above. As per the altitudinal limits in India, resin-yielding trees grow between 450 to 2300 m amsl. The resin tapping industry plays an important role in the economy of the country. It not only yields additional revenue worth crores of rupees to the country's exchequer but also provides gainful employment to many people, especially the rural folks. India is the second largest producer of resin in Asia, the first being China. In Himachal Pradesh, the important resin-producing districts are Shimla, Kullu, Kinnaur, Chamba, Kangra, Hamirpur, Bilaspur, Mandi, Sirmour, and Solan.

Material and Method

The secondary information was collected regarding the resin yield and number of resin blazes w.e.f. 2005 to 2020 from Himachal Pradesh State Forest Department.

Exponential smoothing models

Exponential smoothing is a particular moving average technique applied to time series data and to produce smoothed data to make forecast. The exponential smoothing method, weights past observations by exponentially decreasing weights to forecast future values. In exponential smoothing, one or more smoothing parameters are to be determined explicitly and those choices determine the weights assigned to the observations. Single exponential smoothing models for forecasting time series data was used.

In the present study Single Exponential smoothing model was used.

Single Exponential Smoothing (SES) model

Single exponential smoothing (SES) is a procedure that repeats enumeration continuously by using the newest data. Let F_t denote the forecast of the TS at time t and Y_t be the actual value. Then, the forecast error is ($Y_t – F_t$). The method of single exponential forecasting takes the forecast for the previous period and adjusts it using the forecast error. Thus, forecast F_{t+1} for the next period, (t+1) is

$$F_{t+1} = F_t + \alpha (Y_t – F_t)$$

Where F_t is forecast for Y_t and α is the smoothing constant taking values between 0 and 1. A large value of α (say 0.9) gives very little smoothing in the forecast, whereas, a small value of α (say 0.1) gives considerable smoothing. From a grid of values for α (say α = 0.1, 0.2… 0.9), the values that yields the smallest Root Mean Square Error (RMSE) was chosen.

Results and Discussion

Forecasting of the number of blazes by using Exponential smoothing

Forecasting with the help of various linear and non-linear models is based on the assumption that the series is stationary. Often time series are found to be non-stationary which means they are integrated and can be made stationary by differencing the time series. To check the stationarity of the number of blazes Augmented Dickey-Fuller test was used.

Table 1: ADF test statistic value along with p values for number of blazes

	ADF test statistic value	p value

Level (original Time Series)	-2.53	0.368
First differencing	-2.25	0.474
Second differencing	-1.81	0.642
Third differencing	-2.76	0.281

Table 1 indicated that data was not approaching stationarity even after taking third difference, for applying ARIMA models the prerequisite condition is that data should be stationary.

When the time series data does not contain trend and seasonal components, single exponential smoothing model is used.

Table 2: Parameters and smoothing constant value of number of blazes by using Single exponential smoothing model

Single Exponential smoothing model	**Estimate**	**Standard Error**	**t statistic**	**Significance**
α (Smoothing constant)	0.799	0.116	6.887	< 0.001

Table 2 indicated that the value of (smoothing constant) α was found to be 0.799 and the value of standard error was found to be 0.116. The value of the t statistic was found to be significant by applying a single exponential smoothing model.

Table 3: R^2 , RMSE, MAPE, MAE and Normalized BIC value of number of blazes by using Single exponential smoothing model.

R^2	0.915
RMSE	81467.136
MAPE	3.756
MAE	59989.34
Normalized BIC	22.776

Table 3 suggested that the value of R^2 was found to be 0.915 provides confirmatory evidence that single exponential smoothing model was best fit in case of number of blazes.

The value of RMSE was found to be 81467.136 and the value of MAPE was found to be 3.756. MAE and Normalized BIC value was found to be 59989.34 and 22.776.

Table 4: Forecasted values of number of blazes by using single exponential smoothing model

Year	Forecasting value of number of blazes
2023	1365779.94
2024	1320559.15
2025	1275338.36

Table 4 showed the forecasted values of number of blazes for the year 2023, 2024 and 2025.

Forecasting of resin yield by using Exponential smoothing

Table 5: ADF test statistic value along with p values for resin yield

	ADF test statistic value	p value
Level (original Time Series)	-1.07	0.909
First differencing	-3.05	0.170
Second differencing	-1.68	0.690
Third differencing	-3.64	0.466

Table 5 indicated that data was not approaching stationarity even after taking third difference, for applying ARIMA models the prerequisite condition is that data should be stationary.

When the time series data does not contain trend and seasonal components, single exponential smoothing model was used.

Table 6: Parameters and smoothing constant value of resin yield by using Single exponential smoothing model

Single Exponential smoothing model	Estimate	Standard Error	t statistic	Significance
α (Smoothing constant)	0.845	0.131	6.435	< 0.001

Table 6 indicated that the value of the smoothing constant was found to be 0.845 and the value of standard error was found to be 0.131. The value of the t statistic was found to be significant by applying a single exponential smoothing model.

Table 7: R^2 , RMSE, MAPE, MAE and Normalized BIC value of resin yield by using Single exponential smoothing model

R^2	0.895
RMSE	3999.501
MAPE	4.728
MAE	2856.49
Normalized BIC	16.761

Table 7 suggested that the value of R^2 was found to be 0.895 provides confirmatory evidence that single exponential smoothing model was best fit in case of resin yield. The value of RMSE was found to be 3999.501 and the value of MAPE was found to be 4.728. MAE and Normalized BIC value was found to be 2856.49 and 16.761. The results were in close affinity with the findings of Eva and Oskar (2012).

Table 8: Forecasted value of resin yield by using single exponential smoothing model

Year	Forecasting value of resin yield
2023	57144.57
2024	55319.44
2025	53494.31

Table 8 showed the forecasted values of resin yield for the year 2023, 2024 and 2025.

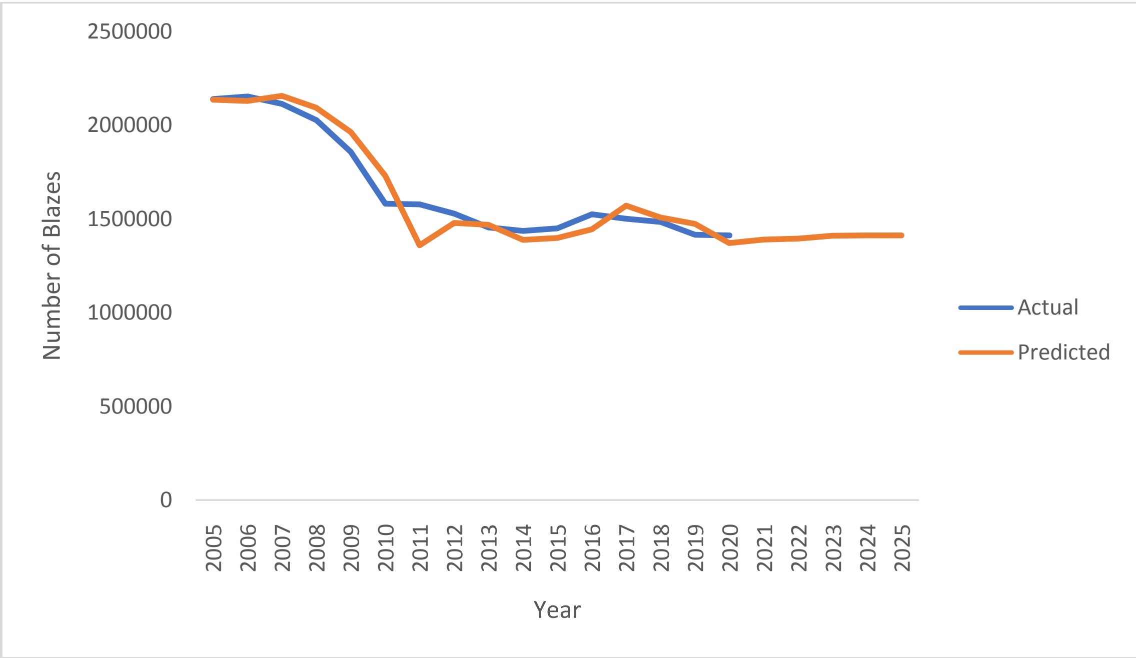

Fig 1: Actual and predicted values of number of blazes by using single exponential smoothing model

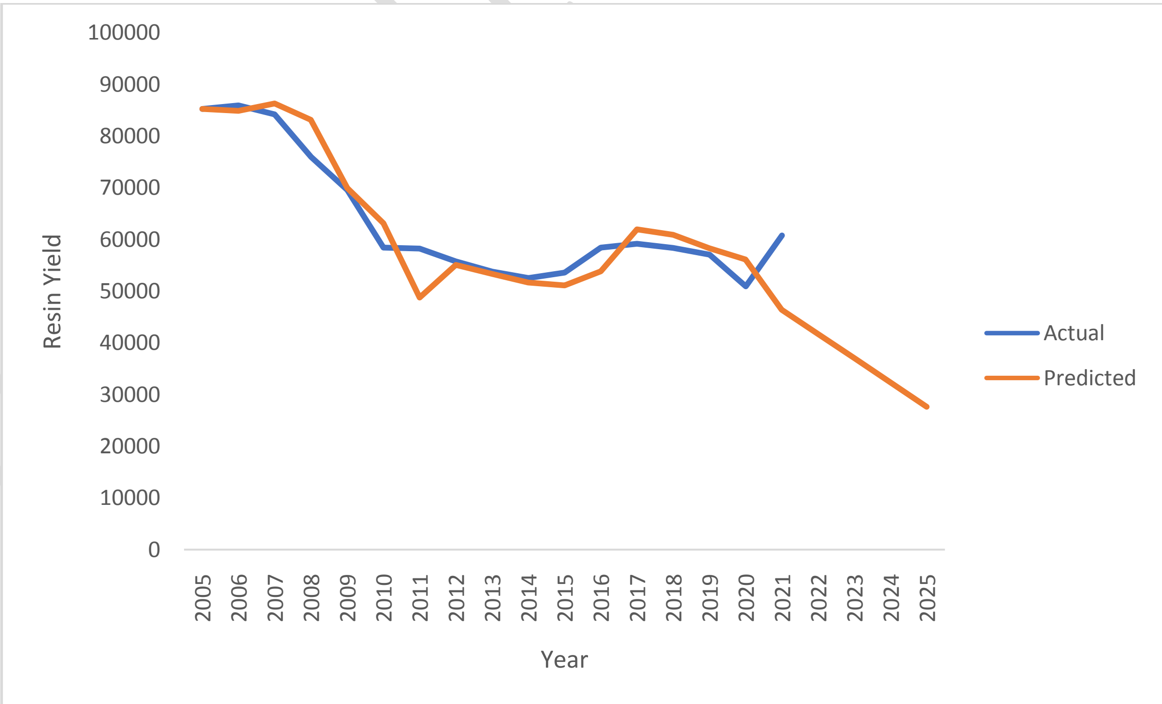

Fig 2: Actual and predicted values of resin yield by using single exponential smoothing model.

Conclusion

The results indicated that data was not approaching stationarity even after taking third difference. So, the prerequisite condition of ARIMA model is that the data should be stationary and if the time series data does not contain trend and seasonal components, Single Exponential Smoothing model was used. The Single Exponential Smoothing model was found to be best fit for prediction of number of blazes and resin yield as per the high value of R^2, low value of MAPE and Normalized BIC.

Author's contributions

The work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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