TIME SERIES MODEL FOR PREDICTING PRODUCTION OF TOBACCO IN INDIA

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ABSTRACT

The present research study was carried out to identify the appropriate time series model for predicting production of Tobacco in India by using Box-Jenkins Auto Regressive Integrated Moving Average (ARIMA) models for the period 1950-51 to 2016-17.The validity of the models were statistically tested by on the basis of goodness of fit criteria's *viz.,* Highest R^2, Lowest Root Mean Square Error (RMSE) and Mean Absolute Percentage Error (MAPE). Among all the models ARIMA (2, 0, 3) model was found to be the best fitted model for predicting production of Tobacco in India for further five years. The forecasted results showed for production of Tobacco for the year 2021-22 is to be 686.2thousand tonnes. And the results showed, there is a decreasing trend on production from 2017-18 to 2020-21 and then increased on 2021-22.

KEYWORDS: Tobacco, production, time series and ARIMA model.

INTRODUCTION

Tobacco (*Nicotiana tabacum*) is an annually-grown herbaceous plant. It was introduced into India by Portuguese traders during AD 1600. India is the world's 2nd largest producer of tobacco with an estimated annual production of around 800 million kg. Tobacco occupies a meagre 0.24% of the country's total arable land area. It is grown largely in semi-arid and rain-fed areas where the cultivation of alternative crops is economically unviable. Andhra Pradesh, Gujarat, Karnataka, Maharashtra, Bihar and Tamil Nadu were the leading tobacco producing states in India. Its leaves are commercially grown in many countries to be processed into tobacco. The tobacco industry in India includes the production, distribution and consumption of (i) Leaf tobacco, (ii) Smoking products such as cigarettes and beedis and (iii) various chewing tobacco products. Tobacco has developed as a cash crop because its contributing substantially to the total agricultural income, yields high net returns per unit of cultivation as compared to other crops, employment opportunities, both in agriculture and activities involved in the manufacture of tobacco products, a major foreign exchange earner. The production of tobacco in India 806 thousand tonnes in 2016-17 (www.indiastat.com).

Prabakaran and Sivapragasam (2014) were studied forecasting areas and production of rice in India using ARIMA models. It was found that the forecasted rice cultivated areas and production were to increase in the next four years.

Baser *et al.* (2018) fitted ARIMA model for Forecasting Chestnut Production and Export of Turkey for the period of 1961-2016. They obtained ARIMA (1, 1, 1) and ARIMA (1, 2, 1) models were best fitted models and they conclude that Turkey's chestnut production and export would be increased in the forecasted years.

Murthy *et al.* (2018) was made an attempt to develop an appropriate ARIMA model for forecasting groundnut area, production and productivity of India. They have concluded that ARIMA (2, 1, 3), ARIMA (3, 0, 3) and ARIMA (2, 1, 3) models were best fitted to forecast area, production and productivity of groundnut in India. For four leading years, they have found that there was a decreasing trend on area and fluctuations on production and productivity from the period 2016-17 to 2019-2020.

Murthy *et al.* (2018) studied the appropriate ARIMA model for forecasting sunflower production in India and they found that ARIMA (4, 1, 4) model was the best fitted model to forecast Sunflower Production in India and also they were observed that there is a downward and upward trend on production of sunflower in India for forecasted years.

The objective of the present study is to identify the appropriate time series model for predicting production of Tobacco in India by using Box-Jenkins Auto Regressive

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Integrated Moving Average (ARIMA) model, and also to forecast next five year future values based on selected model.

MATERIAL AND METHODS

The data of study for a period of 67 years (1950-51 to 2016-17) in India pertaining to Production ('000 tonnes) of Tobacco was collected from the source of Govt. of India in www.indiastat.com. In order to examine the nature of change in production of Tobacco in India by ARIMA time series models was worked out by using statistical package SPSS 22 version.

Auto Regressive Integrated Moving Average (ARIMA)

The ARIMA methodology is also called as Box-Jenkins methodology (Box and Jenkins 1976). Box and Jenkins (1976) established that these parameters can be obtained through trial and error approach after examining the Auto Correlation Function (ACF) and Partial Auto Correlation Function (PACF). The first step in developing ARIMA model is to examine data for stationarity. This can be identified through Auto Correlation Function (ACF) of actual data, if the auto correlation function does not die out rapidly, it indicate that the data are non-stationary. Under this situation, the auto correlation corresponding to most of lags are statistically significant. For reducing the data to stationarity, the data are therefore transformed by taking first order differences (d = 1). If the auto correlation functions of differenced data indicate a rapid decrease, then it can be concluded that the transformed data is stationary. If not again the data has to be transformed by taking second order differences (d = 2). Continuing in a similar way as that of d = 1, the order of differencing *i.e.*, d can be determined. After determining the differencing order 'd', the order of auto regressive (p) and moving average (q) components, can be obtained as follows:

If the auto correlation function corresponding to the transformed data decays after the qth lag, then it is taken as MA (q) model; likewise, if partial auto correlation function indicates a decaying after p^{th} lag, it indicates existence of AR (p) model *i.e.,* the characteristics p and q are determined on the basis of PACF and ACF of the stationary data.

The Box-Jenkins procedure is concerned with fitting a mixed ARIMA model to a given set of data. The main objective in fitting ARIMA model is to identify the stochastic process of the time series and predict the future values accurately. This method shave also been useful in many types of situations which involve the building of models for discrete time series and dynamic systems. However the optimal forecast of future values of a time series are determined by the stochastic model for that series.

The ARIMA (p, d, q) process is given by

$$Y_t = \theta_0 + \phi_1 y_{t-1} + \phi_2 y_{t-2} + \ldots +$$

$$\phi_p y_{t-p} + \varepsilon_t - \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} \ldots -\theta_q \varepsilon_{t-q}$$

where y_t and ε_t are the actual value and random error at time period t, respectively.

ϕ_i (I = 1, 2, ……, p) and ϕ_j (j = 1, 2, ……, q) are model parameters. p and q are integers and often referred to as orders of the model. Random errors ε_t are assumed to be independently and identically distributed with a mean of zero and a constant variance of σ^2.

The main stages in setting up a Box-Jenkins forecasting model are as follows:

1. Identification   2. Estimating the parameters

3. Diagnostic checking 4. Forecasting

RESULTS AND DISCUSSION

In the present study, the data for production of Tobacco in India for the period of 67 years (1950-51 to 2016-17) were used for the study.

(a) Model Identification

Among several models of ARIMA (p, d, q) studies the goodness of fitted models were examined by highest R^2 value, lowest RMSE (Residual Mean Square Error) and lowest MAPE (Mean Absolute percentage Error) values. Based on these criterions, it was found that ARIMA (2, 0, 3) are the best fitted model for forecasting Tobacco production in India. The Coefficient of determination (R^2), Mean Absolute Percentage Error (MAPE) and Residual Mean Square Error (RMSE) are given by

$$R^2 = 1 - \left[\frac{\sum_{i=1}^{n}(y_t - \hat{y}_t)^2}{\sum_{i=1}^{n}(y_t - \overline{y})^2} \right]$$

$$\text{MAPE} = \frac{100}{n}\sum_{i=1}^{n}\left|\frac{y_t - \hat{y}_t}{y_t}\right|;$$

$$\text{RMSE} = \sqrt{\frac{\sum_{i=1}^{n}(y_t - \hat{y}_t)^2}{n}}$$

where y_t is the actual observation for time period 't' and $\hat{y}_t$ is the predicted value for the same period and $\overline{y}$ is the overall sample mean of observations. The models and the corresponding values are shown in Table 1.

Table 1. ARIMA (p, d, q) models for production of tobacco in India

ARIMA (p, d, q)	R Square	RMSE	MAPE
ARIMA (1, 0, 1)	0.84	64.68	11.60
ARIMA (1, 1, 1)	0.83	65.82	11.90
ARIMA (1, 2, 1)	0.78	74.79	13.39
ARIMA (2, 0, 3)	**0.85**	**63.93**	**11.46**
ARIMA (2, 1, 3)	0.84	65.50	11.49
ARIMA (2, 2, 2)	0.81	71.16	12.60
ARIMA (3, 0, 2)	0.84	64.85	11.51
ARIMA (3, 1, 2)	0.84	66.04	11.61
ARIMA (3, 2, 1)	0.80	72.62	12.92

(b) Model Estimation and Verification

The parameters of the model were estimated by using SPSS 22 version. The ARIMA (2, 0, 3) was found to be best fitted model for production of Tobacco. The model verification (or) diagnosed by the Ljung-Box Q statistic. The Ljung-Box Q statistic is to check the overall adequacy of the model. The test statistic Q is given by

$$\sigma_n = nr(nr+2)\sum_{i=1}^{n}\frac{r_l^2(e)}{nr-1}$$

where $r_l(e)$ is the residual autocorrelation at lag l, nr is the number of residual, n is the number of time lags

included in the test for model to be adequate, p-value associated with Q statistics should be large (p-value>α). The results of estimation are reported in Table 2.

(c) Test for randomness of residuals

Non-parametric one sample run test can be used to test the randomness of residuals. For small samples *i.e.,* both n_1 and n_2 are equal to or less than 20 if the number of runs 'r' fall between the critical values, we accept the H_0 (null hypothesis) that the sequence of binary events is random otherwise, we reject the H_0. For large samples *i.e.,* if either n_1 or n_2 is larger than 20, a good approximation to the sampling distribution of r (runs) is the normal distribution, with mean

and standard deviation

$$\sigma_r = \sqrt{\frac{2n_1 n_2 (2n_1 n_2 - n_1 - n_2)}{(n_1 + n_2)^2 (n_1 + n_2 - 1)}}$$

Then, H_0 may be tested by $z = \dfrac{r - \mu_r}{\sigma_r}$

The significance of any observed value of Z computed from the above formula may be determined by reference to the standard normal distribution Table 3.

(d) Forecasting with ARIMA model

After the identification of the model and its adequacy check, it is used to predict the production of Tobacco for the next five periods. Hence we used the identified ARIMA model to predict production of Tobacco for the years 2017-18 to 2021-22. The predicted results are presented in Table 4. The ACF and PACF of residuals of fitted ARIMA model for Tobacco production are presented in Fig. 1 and also the diagrams of actual and predicted values are presented in Fig. 2.

CONCLUSION

In the present study, the identified ARIMA (2, 0, 3) was the best model for forecasting the Tobacco production based on highest R^2, lowest RMSE and MAPE criterions in India. The study revealed that the trend on production of tobacco was decreased from 2017-18 to 2020-21 and then trend increased on 2021-22. Due to Uncertain

Table 2. Estimates of the fitted ARIMA (2, 0, 3) models for tobacco production in India

Tobacco	Model fit Statistics			Ljung-Box Q	
	R-square	RMSE	MAPE	Statistic	p-value
Production	0.85	63.93	11.46	13.094	0.441

Table 3. Test for randomness of the residuals for fitted model of tobacco production

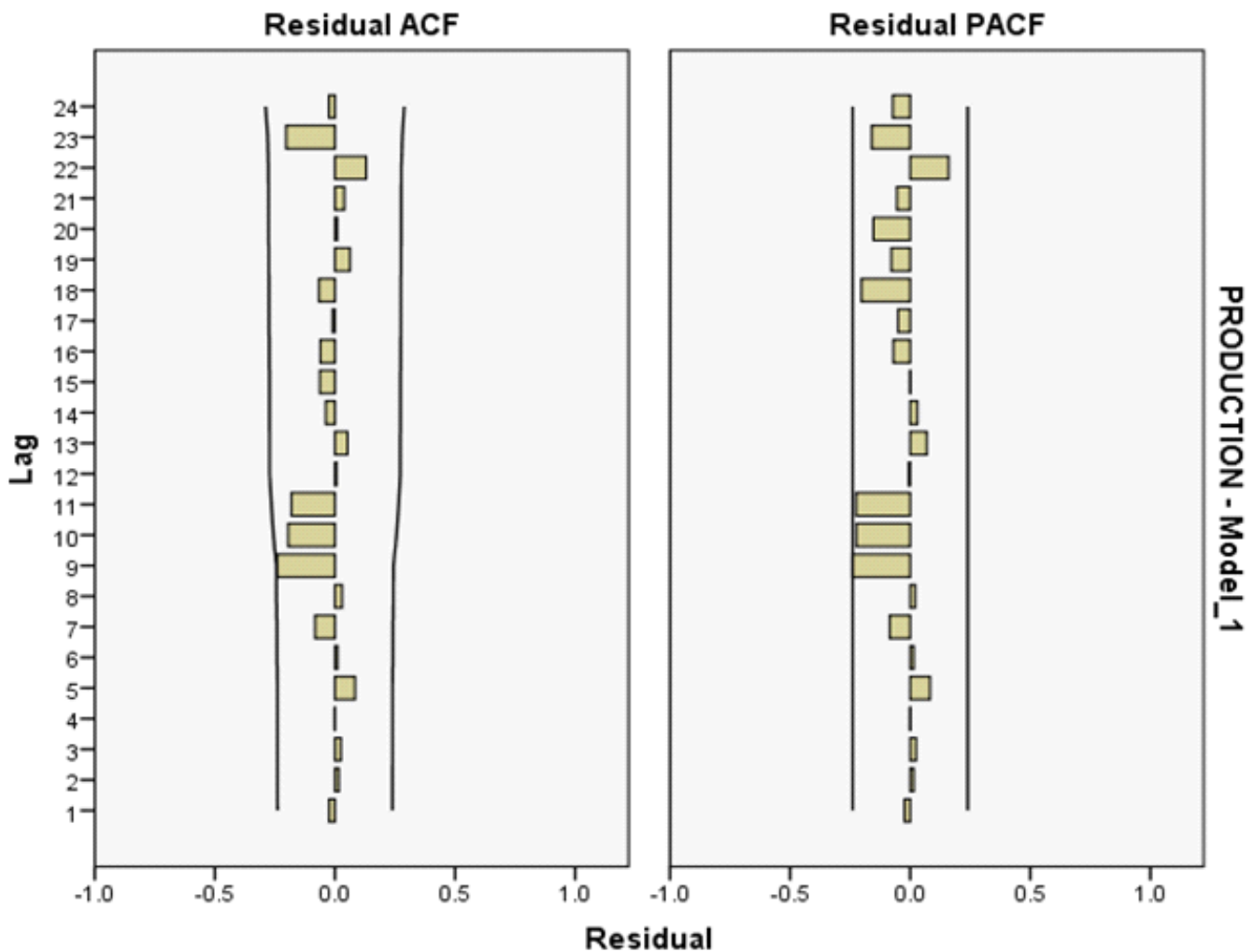| Model	Run test for residuals			
	Total cases	No. of runs	|z|-value	p-value
Production : ARIMA (2, 0, 3)	67	33	0.368	0.713

Fig. 1. The ACF and PACF of residuals of fitted ARIMA (2, 0, 3) model for tobacco production.
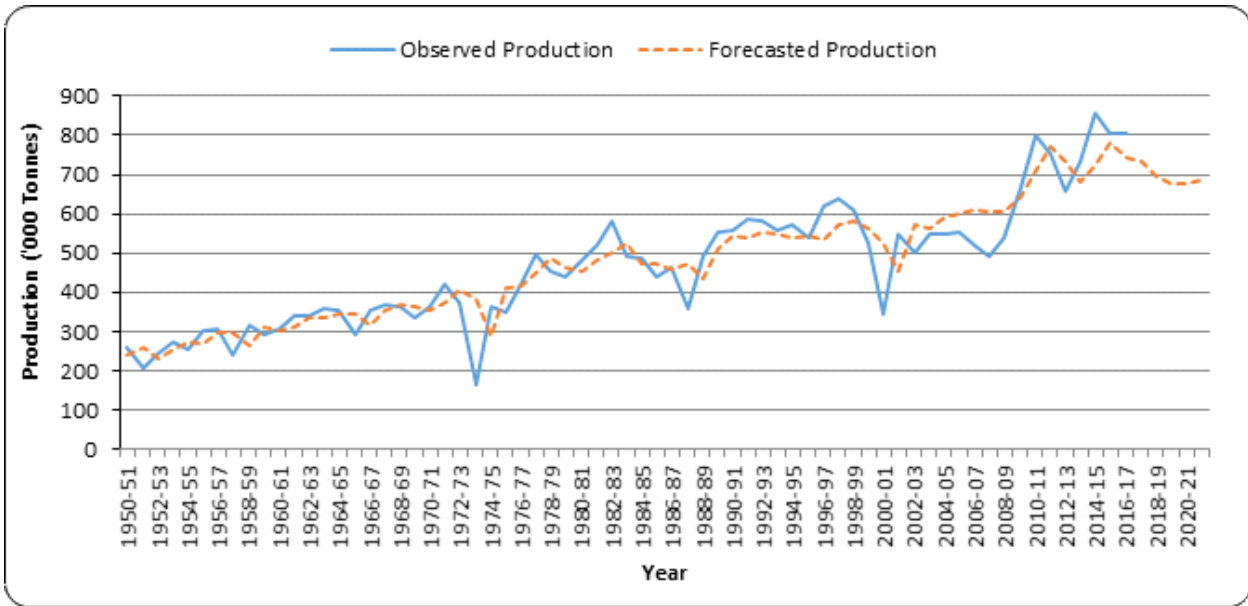
Fig. 2. Observed and predicted tobacco production (1950-51 to 2021-22).

Table 4. Predicted values of tobacco production in India from 2017-18 to 2021-22

Year	Tobacco production ('000 Tonnes)
2017-18	732.7
2018-19	694.7
2019-20	678.4
2020-21	678.3
2021-22	686.2

Monsoons and Inadequate Irrigation Facilities, low price in market etc., the production of tobacco was fluctuated. All parts of the plant contain nicotine, which can be extracted and used as an insecticide. Tobacco is a great pest poison for the garden, and tobacco leaves has so many uses. So that, the agricultural farmers should take more attention to increase the production of Tobacco in India by using new technologies in cultivation.

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