

Original Research Article

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Application of Arima Models in Millet Production in Andhra Pradesh

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ABSTRACT

The study was intended to check and identify the best prediction model of Millet production in Andhra Pradesh through Auto Regressive Integrated Moving Average (ARIMA). Time series data on production of Millet for a period of 56 years (1963-2019) was used. The ARIMA (1 1 1) model was identified as the appropriate procedure for the Millet production up to 2024. It was observed that there was a growing production.

Introduction

Millet locally known as “Bajra (Pearl millet)” is a nutritious coarse grain cereal. Worldwide, it is grown on an area of 34.6 million ha with annual production of 28.8 million tons (FAO, 2005). Millet is grown as food and fodder in arid and semi arid tropical environments. It is an important source of fodder in many countries of the world (Bhatnagar *et al.*, 1998). It has high dietary value as nourish for poultry and livestock. Its cultivation in crop rotation has been shown to reduce nematode problems in wheat, soybean and potato. Millet is considered as the fifth important cereal

crop, and most important millet (constitutes more than 55% of global millet production) and is grown in over 40 countries, predominantly in Africa and the Indian subcontinent.

Ahmad *et al.*, (2005) attempted ARIMA models to forecast growth trends of production and export of Kinnow from Pakistan up to 2023 and concluded that there will be increase in trend in the coming years

Iqbal *et al.*, (2005) forecasted the wheat area and production in Pakistan up to 2022 and found that the cropped area and output would

increase in future, if the soil conservation and reclamation measures are adopted.

Goldsmith and Masuda (2009) used time-series models to forecast world soybean production and harvested area up to 2030 by developing ARIMA models and found that world soybean production is predicted to increase about 2.2% annually.

Badmus *et al.*, (2011) attempted Nigeria Maize production and harvested Area and concluded that production and harvested Area will expect to increase in next year's using ARIMA models. The purpose of the this study is to forecast millet production, using time series AARIMA models

Materials and Methods

The time series data were obtained from Directorate of Economics and Statistics, Andhra Pradesh.

Of the Time series data on production of Millet for a period of 56 years (1963-2019) was used for the model. The time series models were applied on the data.

In this study Box and Jenkin's methodology ARIMA model was used and predict upcoming millet production in Andhra Pradesh. Used various ARIMA models and identify the best appropriate fitting model. For this study, normality test, detection of outlier and residual analysis were used for process of building the time series models. The Statistical software Minitab and Gretl is used for modeling and predicting millet production time series of Andhra Pradesh.

Shapiro-Wilks Normality test

Normality of the data is one of the important assumption on the time series. The null hypothesis is the data belongs to normal.

$$W = \frac{(\sum_{t=2}^n a_t y_t)^2}{\sum_{t=1}^n (x_t - \bar{y})^2}$$

Where, n= number of observation, y_t values of order sample and a_t is tabulated coefficients.

Box-Jenkins Methodology

In an Auto Regressive Integrated Moving Average (ARIMA) the future value of a time series assumed to be a linearly and past observations are random errors. The time series has the form

$$Y_t = \theta_1 Y_{t-1} + \theta_2 Y_{t-2} + \dots + \theta_p Y_{t-p} - \phi_1 \epsilon_{t-1} - \phi_2 \epsilon_{t-2} \dots - \phi_q \epsilon_{t-q} + \epsilon_t$$

Y_t is the time series, p is number of autoregressive parameters, q is number of moving averages. The Box-Jenkins (1970) methodologies were applied forecasting model. For this study, Millet production be a discrete time series variables which takes different variables over a period of time.

Augmented-Dickey Fuller (ADF) test

The unit root test is carried out the by using the Augmented-Dickey Fuller test. The hypothesis of ADF test was time series is stationary and alternative hypothesis is non stationary.

$$\Delta \lambda_t = \alpha_0 + \alpha_2 t + \beta \Delta \lambda_{t-1} k_{i-1} + \epsilon_t$$

Where λ_t indicates the yearly millet production at time t, β is the coefficient to be estimated; k is number of lagged terms, α_2 is estimated coefficient for the trend, α_0 is the constant and ϵ is error term

Mean Absolute Percentage Error (MAPE)

The average of absolute percentage amount by which forecasts differ from outcomes, used

residual analysis for model forecasting. For evaluating the performance of forecasted model

MAPE has been applied, which is defines as

$$MAPE = \frac{1}{n} \sum_{t=1}^n \frac{|a_t - f_t|}{a_t} * 100$$

Where, a_t is Actual data and f_t is Forecasted data with respective time period t

Theil's U Statistic

Model forecast accuracy is plays important role for forecasting of upcoming values. Theil's U test gives us accuracy of the model, U lies between 0 and 1, with values closer to 0 indicates greater forecasting model.

$$U = \frac{\sqrt{\sum_{t=1}^n (a_t - f_t)^2}}{\sqrt{\sum_{t=1}^n a_t^2} + \sqrt{\sum_{t=1}^n f_t^2}}$$

Where, a_t is actual values of time series and f_t is forecasted values

Results and Discussion

For this study, Shapiro –Wilk’s test was used for normality of time series data, the test p-value is 0.1091 which is highly significant at 0.01 level, the null hypothesis is a sample belongs to a normal distribution the study shows distribution of the data are not significantly different from normal distribution. The study here employs the unit root test to examine the time series data is stationary or not. For the test of ADF test was -15.244, which is significantly at 0.05 levels,

reject null hypothesis and considered as the time series data has stationary, which means the time series data follows stationary at first difference.(Table 1).

The suitable ARIMA model concerned with examination of residual of the model in systematic way, which is helpful for improve the time series ARIMA model.

The Auto Correlation Function (ACF) and Partial Auto Correlation Function (PACF) were used for order of ARIMA model, It is helpful for time series data has been stationaries by differencing (Figure:1 and 2).

The appropriate models were identified through the procedure of Box-Jenkins’s methodology (ARIMA).

From the various forms of following ARIMA (p d q) models viz ARIMA (1 0 1); ARIMA (1 1 1), ARIMA (0 1 1), ARIMA (1 1 0) and ARIMA (1 0 0); the best model was chosen on the basis of high coefficient of determination, low Mean Absolute Percentage Error (MAPE) and lesser Theil U-Statistics.

Among the comparison of ARIMA models, the ARIMA (1 1 1) model was high R-square value 0.710 which significantly at 0.01 level and MAPE is 14.798 and their Theil’s Statistic is 0.698, it indicates better accuracy forecasting model comparing other ARIMA models (Table 2). The output has shown between 1963 and 2019 millet production is of yearly increasing. In view of residual analysis for ARIMA (1 1 1) being an evidence of normality, all the points close to the line, it indicates the model would be good for prediction (Figure 1). In the forecasting of millet production, in the year 2024 highest production

Table.1 Diagnosis of the Model

Diagnosis test	Value	p-value
Shapiro-Wilk's Normality test	0.943	0.1091(p>0.01)
Augmented-Dickey Fuller test (Stationary)	-15.244	0.0282(p<0.05)

Table.2 Represents ARIMA models of Millet production Yield (Kg./Hectare)

ARIMA Model	R-Square	MAPE	Theil's-U Statistic
ARIMA (1 0 1)	0.637**	15.863	0.769
ARIMA (1 1 1)	0.710**	14.798	0.698
ARIMA (0 1 1)	0.695**	15.036	0.712
ARIMA (1 1 0)	0.656**	15.187	0.777
ARIMA (1 0 0)	0.682**	18.221	0.912

Note: ** Significant at 0.01 levels

Table.3 Forecasting model for millet production time series in Andhra Pradesh (Kg./Hectare)

ARIMA (1 1 1)			
Year	Forecast	UCL (95%CL)	LCL (95%CL)
2020	1233.58	1488.78	978.39
2021	1179.36	1434.98	923.74
2022	1217.19	1492.03	942.35
2023	1222.03	1505.66	938.40
2024	1238.69	1533.70	943.68
2025	1251.11	1556.05	946.17

Fig.1 Auto Correlation coefficients of residuals of ARIMA (1 1 1) model for the Millet Production

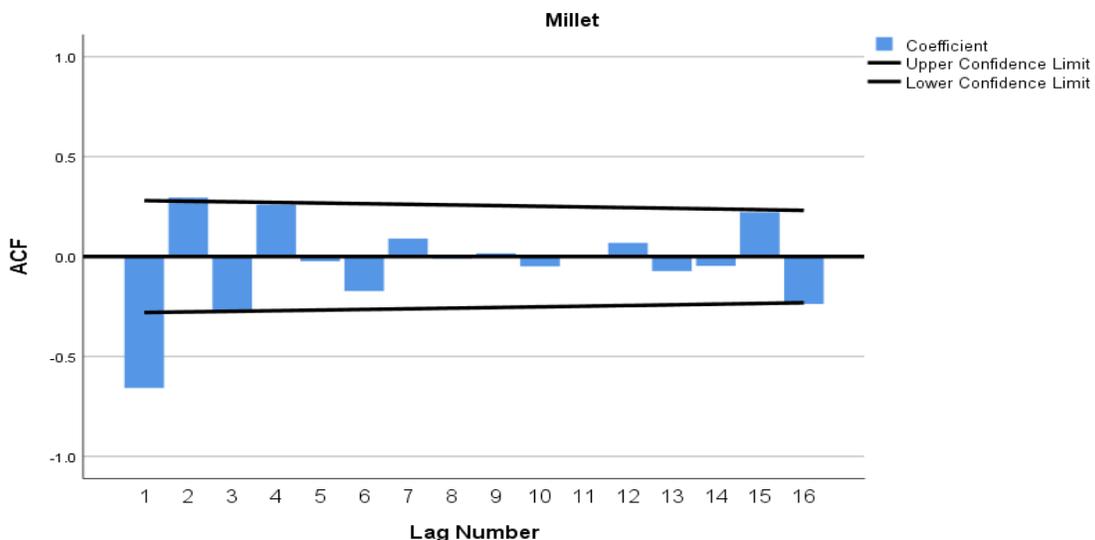


Fig.2 Partial Auto Correlation coefficients of residuals of ARIMA (1 1 1) model for the Millet Production

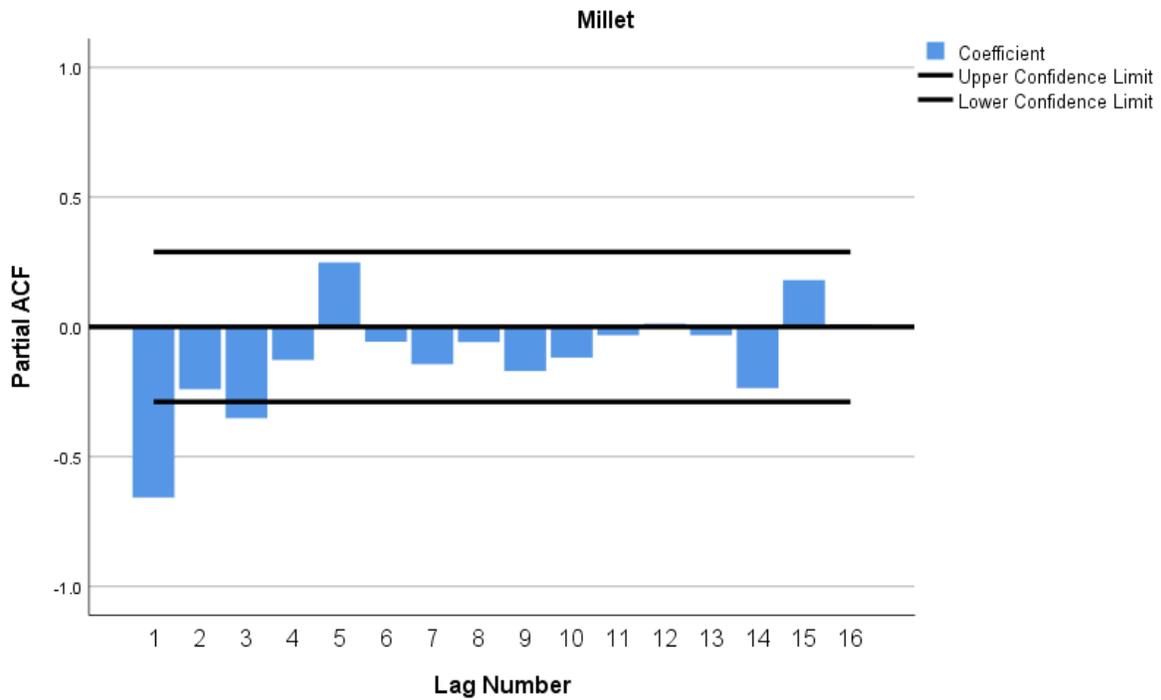


Fig.3 Residual analysis of Millet Production ARIMA (111)

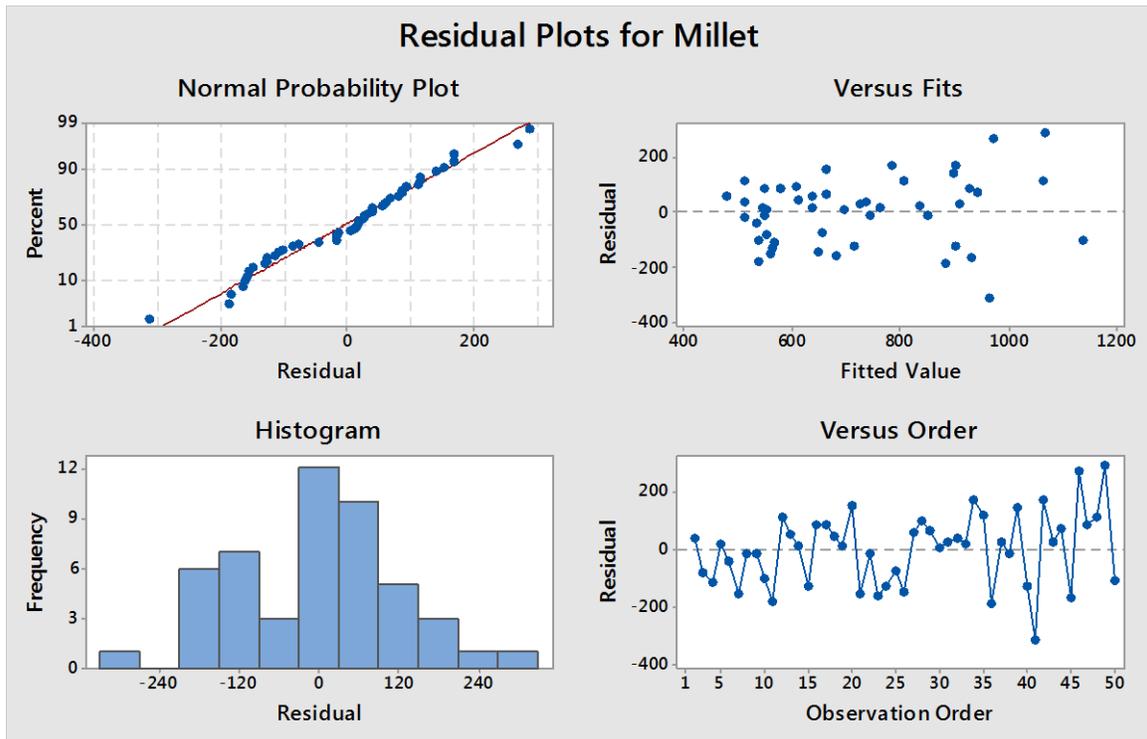
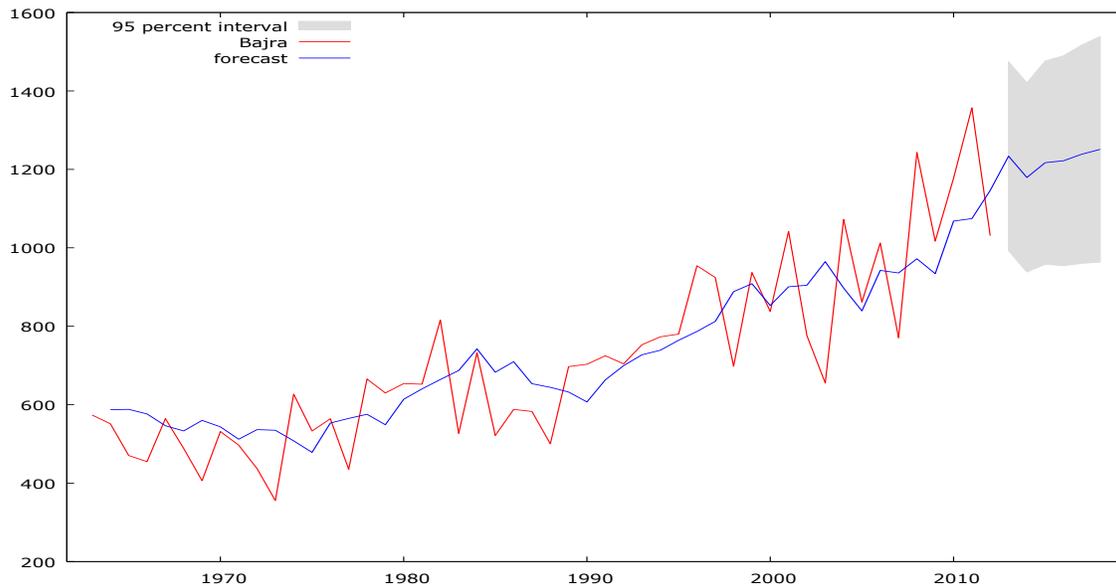


Fig.4 Actual and forecast of Millet production ARIMA (111)



A time series model provides an appropriate techniques for predicting the data of any variable. The study urbanized production of millet model was exponential trend. Overall, the model can be seen that forecasted production of millet has increasing trend over the time period 1963 to 2019 respectively. The ARIMA (1 1 1) model can be used by researchers for the predicting the millet in Andhra Pradesh. However, it should be updated from the over the time period and inclusion of existing data. The time series ARIMA model can be utilized with appropriate results in other traditional models concerning evolution of the production. The time series ARIMA model can be deployed for reaching dependable production forecast for many agricultural produce that have immense policy suggestions.

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