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Forecasting Of Cotton Area, Production, Productivity Using Arima Models In Andhra Pradesh

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ABSTRACT

This study attempted to identify the trend and forecasting of area, production and productivity of cotton in Andhra Pradesh using different ARIMA models. To forecast area, production and productivity ARIMA models, introduced by Box and Jenkins were used. The results of the study based on data during the years 1977-2012. The various ARIMA models were applied and identified area ARIMA (2 1 2), Production ARIMA(2 1 2) and Productivity ARIMA(2 1 1) models. To test accuracy of models Theil's U Statistic were used. Among the ARIMA models their accuracy was area (81.6%), Production (90.1%) and Productivity (82.7%). Residual analysis was used for diagnostic testing. Forecasted values are very close to actual values and have increased is due to availability of Cotton crops in Andhra Pradesh.

Key Words: ARIMA, Residual analysis, Dicky-Fuller test, Theil's U Statistics and R-Square

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INTRODUCTION

Over 60 million people in India cotton is the livelihood farming textile and trade sector. About 365 lakhs bales of cotton production in the country for the year 2012. It is second largest in the world next to China. Over the time India has achieved significantly in quantitatively cotton production with available technology.

Various authors have been attempted models for past to develop forecast models for various crops. Paul et al.[1] have studied fluctuations in export prices of spices; Chandran and Pandey [2 have forecasted seasonal fluctuations in potato prices in Delhi; Paul and Das [3] have studied forecasting of inland fish production in India using Box-Jenkin's method. Paul [4] studied the stochastic modeling for forecasting of wholesale prices of Rohu in West Bengal, India.

METHODOLOGY

In this study based on secondary data during the years 1977-2012 for forecasting area, production, productivity of cotton. This data have been collected from Directorate of Economics and Statistics. The study covers 35 data points from 1977 to 2012. Various forecasting models have been used in the literature to forecast time series data, on the other hand Auto Regressive Integrated Moving Average (ARIMA) (p d q) techniques used in this study to forecast area, production and productivity for Andhra Pradesh. Used GRETL software for ARIMA models particularly in Econometrics.

The models for analyzing time series data, the ARIMA models include autoregressive (AR), moving averages (MA) and also integrated process.

The general form of the ARIMA (p,d,q) given below

Autoregressive Model (AR) (p); $Y_t = \theta_0+\theta_1 Y_{t-1} + \theta_2 Y_{t-2}....+\theta_p Y_{t-p} + \epsilon_t$---------(1)

Moving Averages (MA) (q); $Y_t = \theta_0 - \Box_1 \epsilon_{t-1} - \Box_2 \epsilon_{t-2} -...-\Box_q \epsilon_{t-q} + \epsilon_t$ --- (2)

The general form of ARIMA model (p d q) is

$$Y_t = \theta_1 Y_{t-1} + \theta_2 Y_{t-2} + \ldots\ldots + \theta_p Y_{t-p} - \varnothing_1 \varepsilon_{t-1} - \varnothing_2 \varepsilon_{t-2} \ldots \varnothing_q \varepsilon_{t-q} + \varepsilon_t$$

where 'p' is order of autoregressive process, 'q' is order of moving average process, and'd' is order of differencing the series to make it stationary.

In this study used Box-Jenkins procedure of ARIMA modeling for identification, estimation, diagnostic checking and forecasting time series data of cotton of Andhra Pradesh. From starting the stationary can be tested through graphs i.e Partial Autocorrelation Function (PCF) Autocorrelation Function (ACF) and Augmented Dickey-Fuller test (ADF) of unit root. After identification of the model, we estimate model parameters through Ordinary Least Squares(OLS) method. If the model successfully through diagnosis tests, then the estimated coefficient of predicting can be used for future data. In this study used residual analysis of area, production and productivity cotton in Andhra Pradesh. For model accuracy we used Theil's U statistic technique.

Maximum Absolute Error (MAE): It is a measure of accuracy for constructing fitted models, especially in trend estimation. It indicates as percentage

$$\text{MAE (\%)} = \frac{1}{n}\sum_{t=1}^{n} 100 * \frac{e_t}{y_t},$$

Where't' is time period, n is number of observations $e_t = \text{Actual} - \text{Estimated}$

Mean Absolute Percentage Error (MAPE): It is also measure of accuracy for fitted models in estimation.

$$\text{MAPE (\%)} = \frac{1}{n}\sum_{t=1}^{n} 100 * \left|\frac{e_t}{y_t}\right|$$

Theil's U Statistic: The Theil's *U* on the other hand measures how well the model predicts against a 'naive' model. A forecast in a naive model is done by repeating the most recent value of the variable as the next forecasted value.

$$U = \frac{1}{n}\sum_{t=1}^{n-1}\left(\frac{f_{t+1}-y_{t+1}}{y_t}\right)^2 * \left[\frac{1}{n}\sum_{t=1}^{n-1}\left(\frac{y_{t+1}-y_t}{y_t}\right)^2\right]^{-1}$$

RESULTS AND DISCUSSION

Table 1: Results of Unit Root test (Augmented Dickey Fuller test)

Variable	Constant /Trend	Level	Order of Integration
Area	Constant and Trend	-3.6561**	I(1)
Production	Constant and Trend	-1.6571**	I(1)
Productivity	Constant and Trend	-3.59805**	I(1)

Note: ** Significant at 0.01 levels

The results of Augmented Dickey Fuller (Unit Root test) for cotton crop area, production and productivity are given in table 1. The results shows area, production and productivity are stationary at first level, which is highly significant at 0.01 levels. For estimates of cotton area, production and productivity was significantly at different levels (Table:2)

Table 2: Estimates of cotton area, production and productivity, ARIMA (2 1 2)

	Area			Production			Productivity		
Type	Coefficient	SE	p-value	Coefficient	SE	p-value	Coefficient	SE	p-value
Constant	44.195	18.126	0.014*	134.425	49.791	0.0069**	52.397	53.955	0.331NS
AR1	-0.861	0.156	0.000**	-0.425	0.578	0.462NS	-0.538	0.045	0.000**
AR2	-0.872	0.123	0.000**	-0.828	0.204	0.0000**	-0.992	0.018	0.000**
MA1	0.697	0.265	0.008**	-0.002	0.591	0.967NS	0.450	0.110	0.000**
MA2	0.573	0.199	0.003**	0.680	0.461	0.140NS	1.000	0.178	0.000**

Note: ** Significant at 0.01 levels and * Significant at 0.05 levels NS: Not significant at 0.05 levels

Used various combinations of ARIMA (p d q) in this study, appropriate models were selected based on criterion selection. Among the ARIMA model selected based on lowest Bayesian Information Criteria (BIC), lowest Akaike Information Criteria (AIC) and Theils U Statistic.
As per criteria of selection of ARIMA models were found best of area ARIMA (2 1 2), production ARIMA (2 1 2) and productivity ARIMA (2 1 2). The accuracy of model was found area (81.65), production (90.1%) and productivity (82.7%) respectively. It is good forecasted model for three variables. And also Mean Absolute Percentage Error (MAPE) was area (11.84%), production (23.95%) and productivity (19.41%) respectively.

Table 3: Residual analysis of ARIMA (2 1 2) of area, production and productivity

Residual Analysis	Area	Production	Productivity
Mean Absolute Error (MAE) (%)	97.25	276.09	289.7
Mean Absolute Percentage Error (MAPE) (%)	11.84	23.956	19.417
Theil's U Statistic (%)	81.6	90.1	82.7
Bayesion Information Criteria (BIC)	452.1210	531.573	521.923
Akaike Information Criteria (AIC)	461.453	540.905	531.255

Table 4: Forecasted values of area, production and productivity

Year	Area ('000 ha)	Production ('000 tonnes)	Productivity (Kg ha^{-1})
2013	817.1	4528.4	2487.91
2014	1993.0	5294.1	2886.51
2015	2016.3	5579.1	2923.53
2016	1963.6	5126.9	2640.65
2017	2109.5	5386.1	2888.74
2018	2150.7	5953.2	3168.53
2019	2180.8	5800.3	2904.36
2020	2229.7	5698.7	2901.47

The forecasted trend values shows in the graphs 1,2 and 3. It is increasingly in area, production and productivity. The graph shows 95% confidence interval lower limit and upper of cotton area, production and productivity. We observed that graph showing positively increasing for all three variables of cotton.

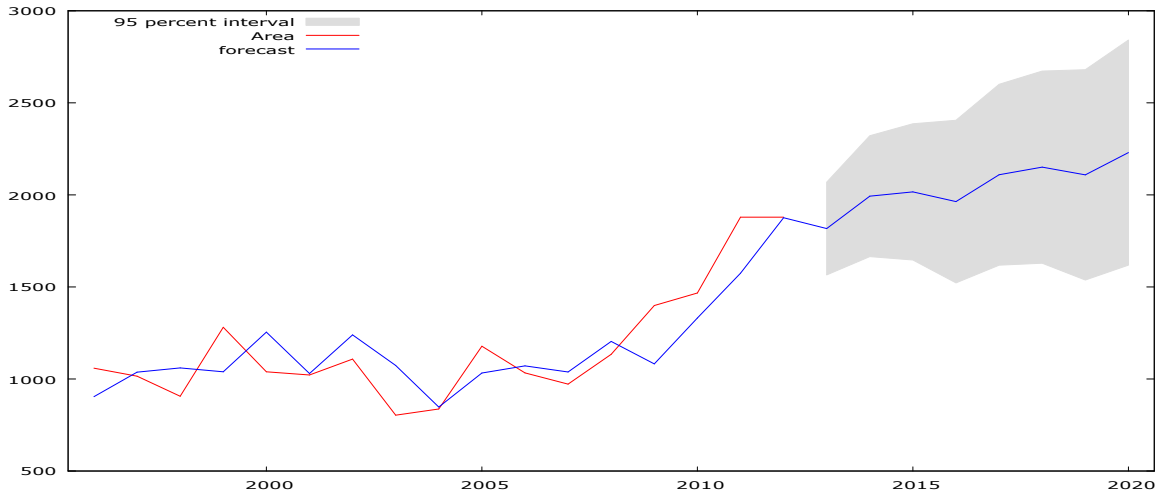

Figure1: Trend and forecasting of Area

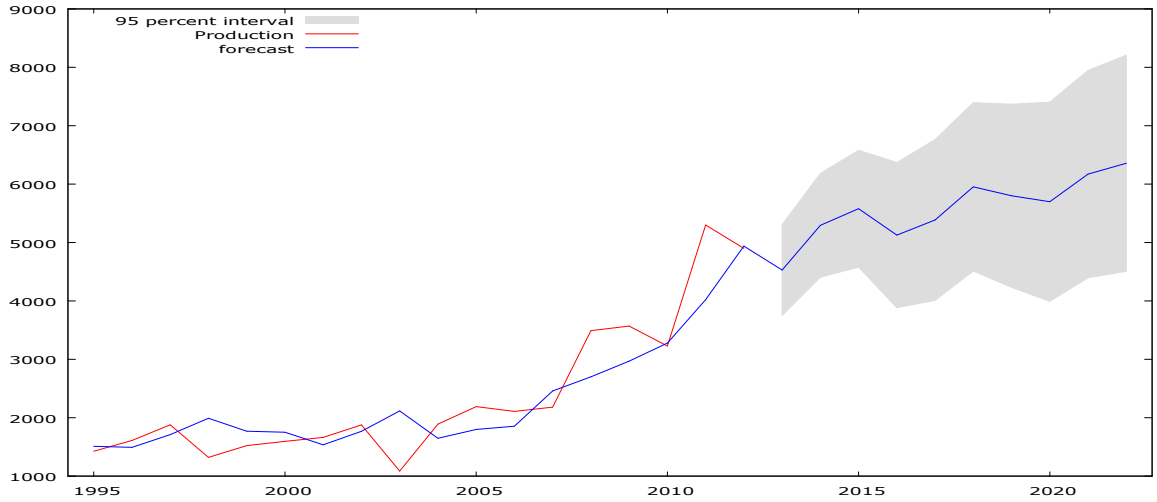

Figure2: Trend and forecasting of production

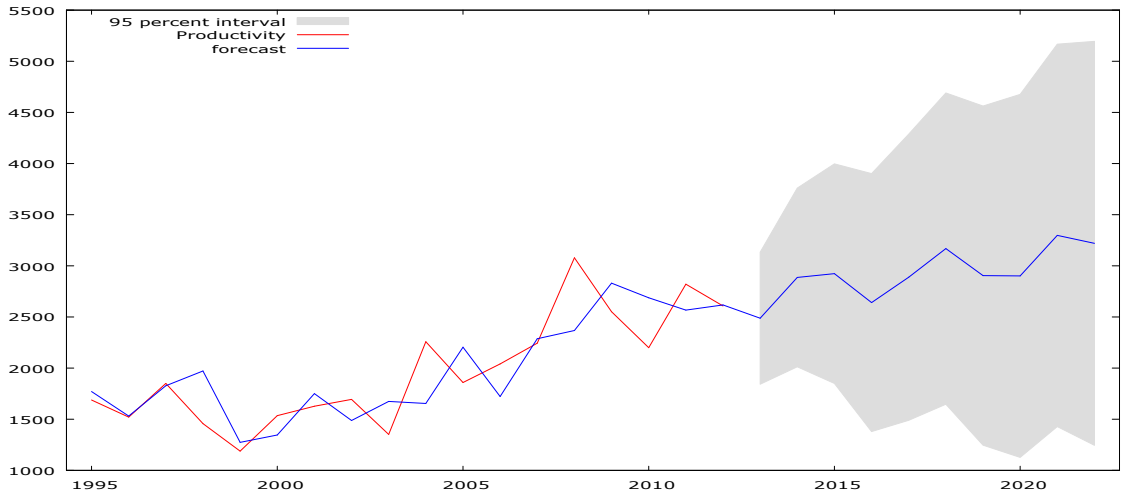

Figure3: Trend and forecasting of productivity

CONCLUSION

The objective of this study was to forecast area, production and productivity of cotton of Andhra Pradesh. Auto Regressive Integrated Moving Average (ARIMA) model were used for this objective. Time series data for 35 years (1977 to 2012) have been used in this study. Box-Jenkin's methodologies were used and forecasted 2013 to 2020. Identified best appropriate ARIMA (2 1 2) model of area, production and productivity of Andhra Pradesh. These forecast values useful to formulating agriculture policy of cotton crop in Andhra Pradesh.

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