A Study on Production of Food Grains in the State of Telangana By Using Box Jenkins's Methodology

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Abstract

In the real mean of research, statistical modeling of non-stationary, non-linear statistics has grown to be a significant challenge. ANN and ARIMA are two of the most widely utilized models. The Artificial Neural Network (ANN) and Box-Jenkin's methods for forecasting the actual production of Food grains crop value in Telangana are compared in this book. The primary goal of this investigation is to create a forecasting model that can accurately anticipate Telangana's agricultural production. In order to predict the annual production of the Food grains crop in Telangana, a statistical forecasting model utilizing Box-Jenkin's approach and artificial neural networks was created throughout this research. The model's ability to forecast was assessed using Mean Absolute Percent Error (MAPE) and Root Mean Squared Error (RMSE). According to the annual projections, Food grains crop production should be 90% accurate over a ten-year period with a regular variance of 1% error measure.

Keywords: *ARIMA; Box-Jenkin's Methodology; ANN; MAPE*

1. Introduction

In many areas of analysis, a statistic is the fundamental subject of the investigation. The underlying presumption of conventional statistic modeling is that the series' past and future values have a linear relationship. For the past few decades, agriculture has been recognized as the backbone of the Indian economy, supporting all crop productivity and growth. One of the most important crops in Telangana, Food grains are grown on 232 lakh tonnes around the Telangana state. It is widely grown in Nizamabad, Siddipet, Suryapet districts. Eating grains, especially whole grains, provides essential fiber, vitamins, and minerals that support digestive health, help control cholesterol and blood pressure, and reduce the risk of chronic conditions like heart disease, type 2 diabetes, and certain cancers. Major food grains in Telangana include rice, maize, and various millets, which are central to the state's agriculture and cuisine. Pulses such as red, green, and black gram are also important for nutrition and improving soil fertility. Food grains provide essential nutrients like complex carbohydrates, fiber, B vitamins, iron, and magnesium, which improve digestion, support heart health, and reduce the risk of chronic diseases like type 2 diabetes and certain cancers. They help regulate blood sugar, manage weight by promoting fullness, and support the nervous and immune systems. This work uses applied mathematics techniques to evaluate the annual production of the Food grains crop in Telangana and forecast it for a short period of time. The results supporting Box-Jenkin's technique and artificial neural networks are shown in the following section.

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2. Materials and Methods

- **Box-Jenkin's Methodology**

In this part, Telangana's Food grains production was modeled. The methodology of Box-Jenkin is mentioned. The general kind of ARIMA (p, d, and q) model is offered by the Box-Jenkin's process, which is related to fitting the associate ARIMA model of the subsequent type for the given collection of information.

$$\Phi(B) \nabla^d Zt = \theta(B)\, at$$

Where $\Phi(B) = 1 - \Phi_1 B - \Phi_2 B^2 - - - - - - \Phi_p B^p$

$(B) = 1 - \theta 1B - \theta 2B^2 - - - - \theta q B^q$

And $\nabla^d = (1 - B)^d$

The white noise process BKZt = Zt–k$anda$t has zero mean and variance $\sigma 2$. The following four steps make up the Box-Jenkin's process. (1) Model Identification, in which the corresponding Autocorrelation function (ACF) and Partial Autocorrelation Function (PACF) behavior is used to determine the orders d, p, and q. (2) Estimation: in cases where the model's parameters are a unit that can be calculated using the highest probability methodology. 3) Diagnostic checking using the "Portmanteau Test," in which the Ljung-Box datum applied to the models residual verifies the suitability of the fitted model. (4) Forecasts are based on the least mean square error methodology for associate degree appropriate models. Stages 1-3 area unit perennials with entirely various values of d, p, and q are used until an acceptable model is found if the model is deemed unsatisfactory (Box et al., 1994).

- **ANN Model**

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The form and practical features of the biological neural network, a potent predictive model, may inspire an artificial neural network, a mathematical model. A bachelor's degree Any nonlinear continuous function can be estimated by an ANN with any level of precision that is needed. It is extensively utilized in the sciences, business engineering, and a variety of sectors. It is essential to many call activities, including designing, scheduling, purchasing, strategy creation, policy-making, and supply chain operations, and it has the ability to make flawless long-term predictions. The non-linear structure, flexibility, knowledge-driven learning approach, and capacity to estimate method universal functions are the features of ANN that make it suitable for predictions. Neural networks have been demonstrated to have the ability to accurately approximate a wide range of sophisticated sensible relationships due to their universal sensible approximating capability. Given that the goal of any prediction model is to precisely capture the beneficial relationship between the variable to be predicted and various pertinent elements or variables, this can be a very significant and potent feature. Because of the combination of the aforementioned features, ANN is a very general and adaptable modeling technique for prediction. ANNs are unit non-linear models, to sum up. The occurrence of numerous non-linear statistical models in the past ten years can be attributed to the fact that global systems are inherently non-linear. (Ramakrishna et al., 2011; Hornik, 1993).

3. Results

- **ARIMA Model for Forecasting the Foodgrains Crop Production**

The development of prediction models' victimization is discussed in this paper. There is mention of Box-Jenkin's system for the annual production of Foodgrains. The Directorate of Economics and Statistics provided the information on Foodgrains production annually from 1979 to 2019, or 40 years (80 seasonal). The model was built using the annual crop output from 1979 to 2011, and the model was validated using the annual Foodgrains crop production from 2011 to 2020. Artificial Neural Networks and Box-Jenkin's approach were used to construct the prediction models for the annual production of Foodgrains crops. With an average yield of 85 lakhs, the Foodgrains crop's annual productivity varied. The time trend of the annual production is displayed in the following chart. About the Foodgrains crop between 1979 and 2019. The Foodgrains crop's annual production displays a non-stationary time trend (Fig 1). Because of the low and high levels of rainfall in the aforementioned years, the average Foodgrains production was relatively low in 2001 and high in 1999 (Fig 1).

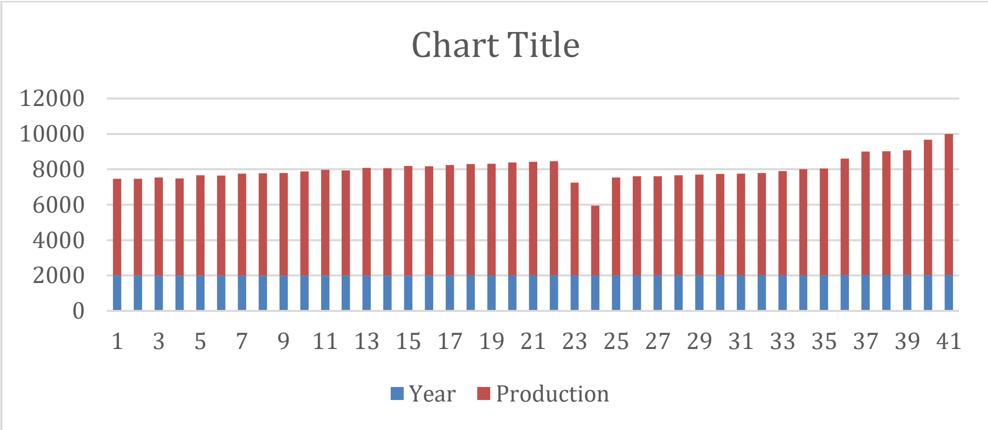
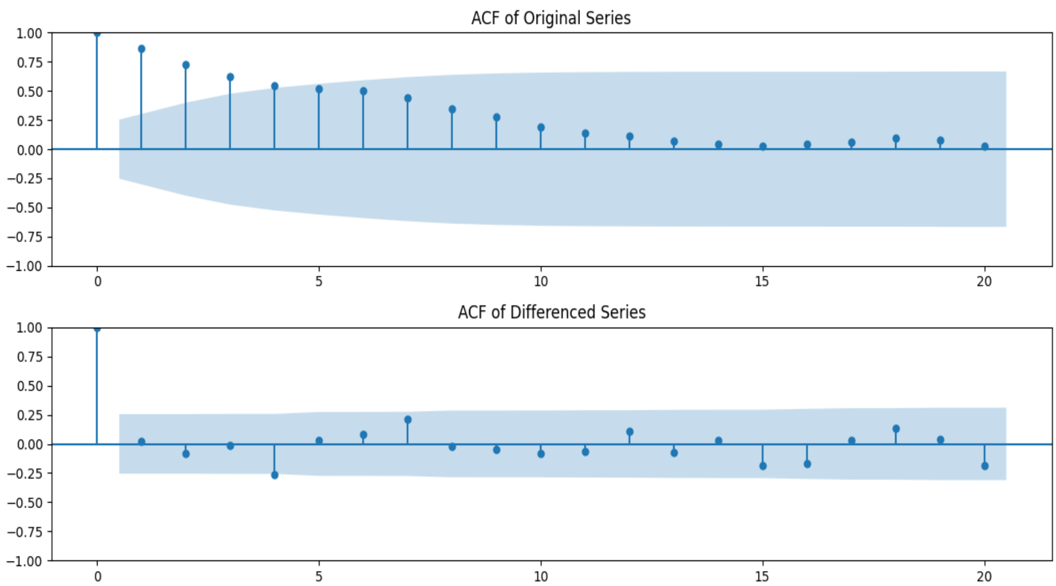


Figure 1: The yearly average for the production of the Foodgrains Crop (in tonnes)

The proficient Python developer was used to figuring out the best ARIMA model for Foodgrains production prediction because this plan automatically finds and estimates the best-fitting ARIMA for one or more variable series, removing the need to find a suitable model through trial-and-error. ACF and PACF order-wise differencing and the validation set with the original series are used to test the ARIMA (0, 1, and 2) model, which is found to match the data well. Tables 1 and 2 below provide the model parameters square measure.

Original Series, Differencing, and ACF (Auto Correlation Function)



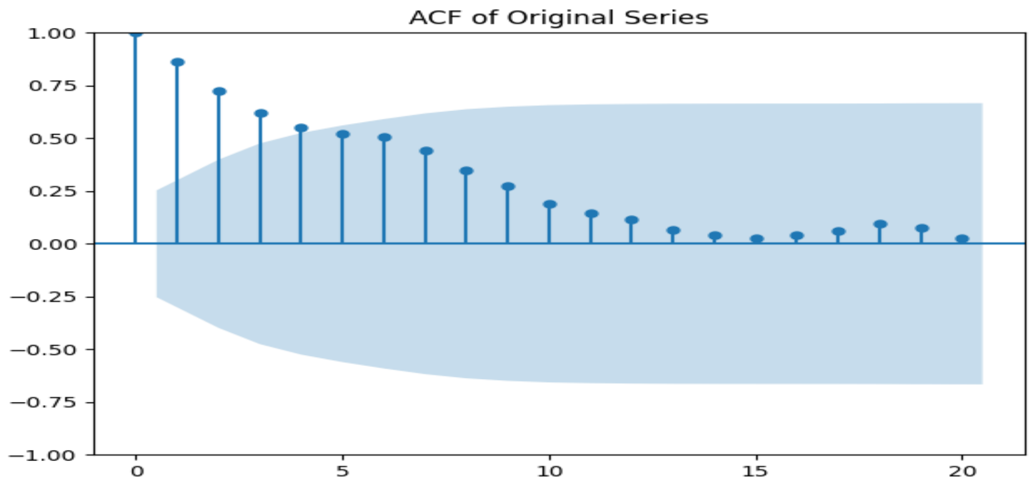


Figure 2: Time series of Foodgrains production (tonnes) in Telangana Original Series with ACF

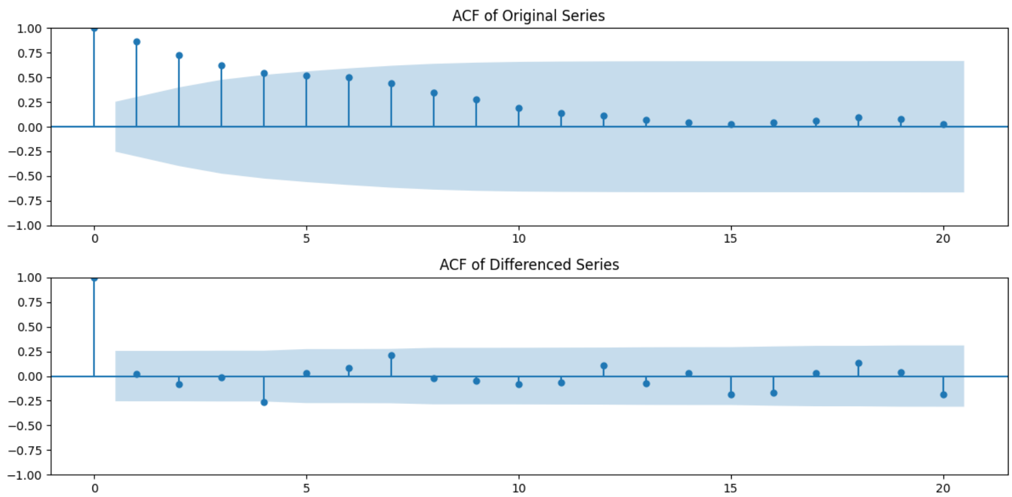
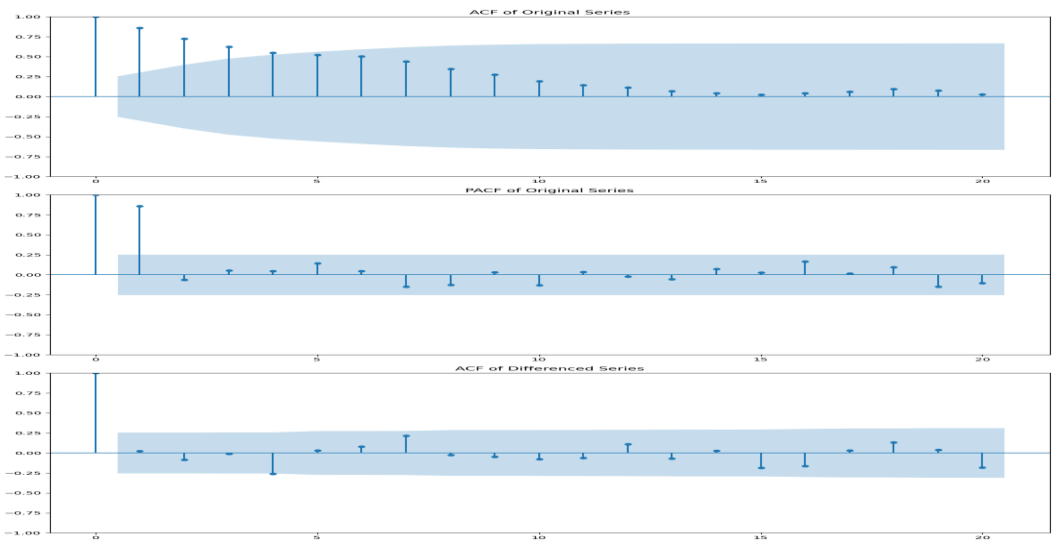


Figure 3: Time series of Foodgrains production (tones) in Telangana 1st Order differencing with ACF

Original Series, Differencing, and PACF (Partial Auto Correlation Function)



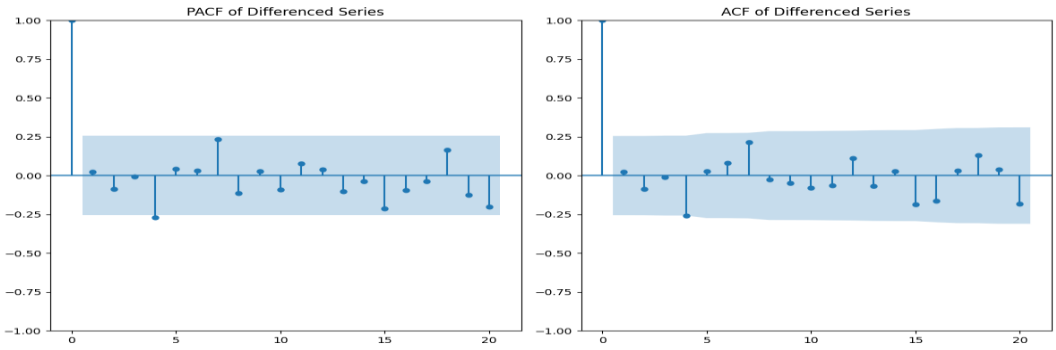


Figure 4: Time series of Foodgrains production (tones) in Telangana, 1st Order differencing with PACF

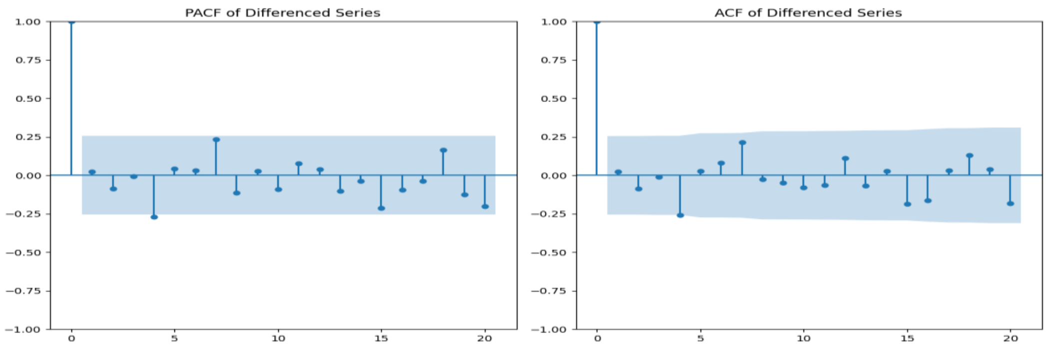


Figure 5: Time series of Foodgrains production (tonnes) in Telangana 1st Order differencing with ACF

Table 1. ARIMA Model Parameters

Best model: ARIMA (0, 1, 1) (0, 1, 2) [0] intercept

SARIMAX Results

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Dep. Variable: y No. Observations: 60

Model: SARIMAX (0, 1, 1) Log Likelihood -485.724

AIC 975.448

BIC 979.603

Sample: 0 HQIC 977.069

- 60

Covariance Type: opg

==

coef std err z P>|z| [0.025 0.975]

Intercept	199.0508	126.627	1.572	0.116	-49.133	447.235
sigma2	8.285e+05	1.76e+05	4.706	0.000	4.83e+05	1.17e+06

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Ljung-Box (L1) (Q):	0.04	Jarque-Bera (JB):	2.30
Prob(Q):	0.85	Prob (JB):	0.32
Heteroskedasticity (H):	1.86	Skew:	-0.46
Prob(H) (two-sided):	0.17	Kurtosis:	2.71

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Hence, the fitted model for the forecasting of Foodgrains production in Telangana is ARIMA (0.1,1) and ARIMA (0,1,2)

$\nabla^1 Zt = (1 + 0.043B^8 - 0.112B^{13})\ at.$

The Ljung-Box q test statistic was used to assess the model's adequacy, and the results showed that Q=1.86 at 20 degrees of freedom. The null hypothesis of the sufficient model was accepted because the corresponding p-value of the letter check datum is 0.85, which is significantly greater than 0.05. As a result, the provided ARIMA (0,1,1) model might be a suitable model for predicting Foodgrains production. In a similar vein, a Python-based model of synthetic neural networks was created to forecast Foodgrains yield.

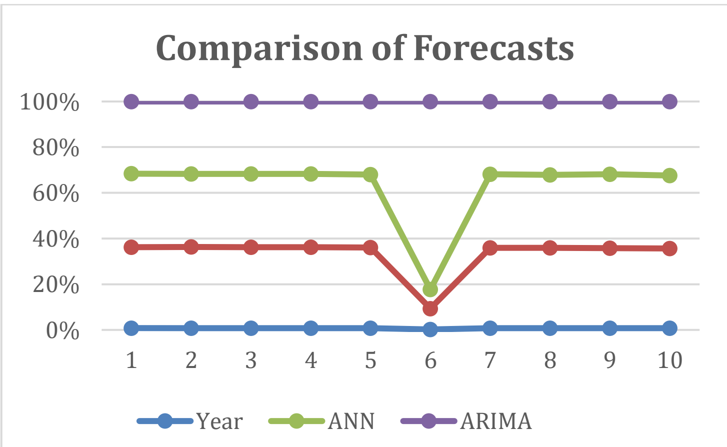

Figure 6: Comparison of forecasts for Foodgrains production in Telangana (in tonnes)

- **Artificial Neural Networks Model**

One input layer, one hidden layer, and an output layer make up an ANN model, which is a feed-forward neural network model. The one-step a head prediction of the silver costs during this ANN model was based on the standardized values of prior observations (Lag-1 or Zt-1). Two hidden neurons make up the hidden layer, which is used to capture the statistic's nonlinearity feature. In the output layer, the identity is utilized as an activation function, whereas in the hidden layer, the hyperbolic tangent function is utilized. A Example feed-forward neural network used to forecast Foodgrains production in Telangana is seen in Figure 6 below. Through trial and error, the ANN model was trained using the exploitation back propagation rule until the testing sample's error measurements were less than those of the coaching sample.

Table 1: Production value

Forecasted values of Foodgrains Production with 94% Confidence Level (CL)

Year	PRODUCTION VALUES		
	Forecasted values	UCL	LCL
2019-20	851	619	91
2020-21	914	557	26
2021-22	863	591	37
2022-23	662	691	18
2023-24	308	691	32

Test for randomness of the fitted ARIMA (4, 1, 4) model

Run Test	Residuals
Total cases	40
Number of runs	14
Z- value	-0.998
Sig (2-tailed)	0.317

In the above table we are observing the production values should be changed according to the conditions and with 95% confidence level.

- **Comparison of Arima and Ann Models**

The training sample contrasted the predictions made by the two models, and the testing samples confirmed the mean absolute error, mean absolute percentage error, and root mean square error. The error measures from the ARIMA and ANN prediction models are shown in the following Table 3.

Table 2. Comparison of the forecasting performance of ARIMA and ANN models

Measure	Training Sample		Testing Sample	
	ARIMA	ANN	ARIMA	ANN
MAE	751.58	852.18	750.19	854.21
RMSE	854.24	862.08	954.08	912.24

MAPE	0.51	0.61	0.52	0.71

In comparison to the ARIMA Model, the ANN model has relatively Foodgrains error measures in the testing sample. In the training and testing samples, the ANN fits the data better than the ARIMA, but it does not perform better in the testing sample. The ARIMA and ANN models' out-of-sample predictions are displayed in figure 7 below. While the ARIMA forecasts display a linear trend over time, the ANN model forecasts display a trajectory that is comparable to the initial expenses. The following table displays the predictions made by the two models.

Table 3. Out-of-sample forecasts of Foodgrains production in Telangana using ARIMA and ANN Models

Production			
Year	**Foodgrains (in tonnes)**	**ANN**	**ARIMA**
2021	91487.25	82892.24	81657.23
2022	92651.24	83456.24	82921.03
2023	93254.89	84547.02	83567.56
2024	93874.21	84895.24	84257.09
2025	94568.45	85567.21	85567.13
2026	94687.21	86027.45	850324
2027	95687.54	87456.2	86762.56
2028	95897.21	87027.69	87532.78
2029	96164.87	88621.01	87562.12
2030	97384.12	89481.09	89812.19
Mean	94565.7	85997.14	161996.4
SD	1791.506	2155.429	241866.4

4. Conclusion

According to the forecasts, the ANN model outperforms the ARIMA model in predicting Telangana's Foodgrains production. While the ANN model displays the nonlinear fluctuations within the forecasts, the ARIMA model only offers linear trends. The analysis found that during the following five years, there will be a decline followed by a gradual increase of Telangana's Foodgrains production. Foodgrains provide essential nutrients like complex carbohydrates, fiber, B vitamins, iron, and magnesium, which improve digestion, support heart health, and reduce the risk of chronic diseases like type 2 diabetes and certain cancers. They help regulate blood sugar, manage weight by promoting fullness, and support the nervous and immune systems.

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