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A COMPARATIVE STUDY OF FORECASTING AGRICULTURAL TIME SERIES: SOME SELECTED FOODGRAIN IN BANGLADESH

By

[1]Md. Salauddin Khan, [2]Masudul Islam, [3]Md. Rasel Kabir and [4]Lasker Ershad Ali

[1]Lecturer, Statistics Discipline, Khulna University, Khulna-9208
[2]Assisant Professor, Statistics Discipline, Khulna University, Khulna 9208
[3]Lecturer, Statistics Discipline, Khulna University, Khulna-9208
[4]Assisant Professor, Mathematics Discipline, Khulna University, Khulna-9208

Abstract

Bangladesh bureau of statistics (BBS) publish a statistical year book in every year where comprehensive and systematic summary of basic statistical information of Bangladesh covering wide range of fields. BBS also forecast different sectors such as economics, weather, agriculture etc in different time in this country. In this paper we mainly concern on the wheat, rice and maize foodgrain which plays a vital role in economic development of Bangladesh. The main purposes of this paper as to compare which techniques are better BBS's or statistical techniques for forecasting. There are different forecasting models are available in statistics among these we used Autoregressive (AR), Moving Average (MA), Autoregressive Moving Average (ARMA) and Autoregressive Integrated Moving Average (ARIMA) models. For this reason, we clarify the stationary and non-stationary series by graphical method. On the basis of that, the stationary model is being set up as the forecasting purpose. After analyze, we compare the forecasting result of our selective foodgrain and find that forecasted values using statistical techniques are nearest to the actual values compare to BBS's projected values.

Keywords- ARIMA, ARMA, Forecast, Foodgrain.

1. Introduction

Food is the premeditated product of the economy of a country and main concern among the necessities of life. Bangladesh is a developing country. So, the issue of food safety is a smoldering problem of the day. Therefore, the authority of Bangladesh should take a right assessment about foodgrain. That's why; Bangladesh Bureau of Statistics (BBS) takes different action to know how amount of foodgrain required producing in Bangladesh. The main foodgrain of Bangladesh is rice, weight, maize etc. The increase of

foodgrain production has resulted from the investment in irrigation fertilizer uses and the adoption and diffusion of improved seeds. Since food is one of the most perceptive items, government polices relating to food occupies a place of considerable importance in the economy of Bangladesh. The study attempts to analyze the policy changes relating to the good economy in Bangladesh as well as the impact of these policies on foodgrain availability. The Bangladesh Bureau of Statistics (BBS) controls most of the largest part of this important sector. Thus, we have to insure that how they estimate of the future production of foodgrain in Bangladesh. In addition, agricultural production is a function of nature, so there is always some degree of uncertainty to achieve the target level of production. As a result, government maintains certain buffer stock of food to combat any unavoidable situation resulting from the nature calamity such as flood, drought etc. Therefore, build up knowledge about foodgrain in any country is very important. So, the government should take a good decision to stock foodgrain in the future.

2. Literature Review

Forecasting is a process in management to support decision making. It is also described as the process of estimation in unknown future situations. Comparing Oscar forecast derived from four data types (fundamentals, polling, prediction markets and domain experts) across three attributes (accuracy, timeliness and cost effective to construct, an attribute the academic literature frequently ignores and update slowly over time, constraining their accuracy (Deepak et al., 2015). The article evaluates and compares the forecasting performance of three international organizations: the United Nations, the International Monetary Fund and the World Bank. The annual forecasts made by the United Nations in the period of 1981-2011 are found to be fairly robust, in terms of bias and efficiency (Pingfan, 2014). It is commonly known as prediction which refers to estimation of time series or longitudinal type data (Abdullah, 2012). Forecasting accuracy drives the performance of inventory management is to investigate and compare different methods like MA and ARIMA with NN models as Feed-forward NN and Nonlinear Autoregressive network with exogenous inputs (NARX) (Mitrea et al., 2009). The most popular model for this method is the Box-Jenkins model introduced by Box-Jenkins has recommended the time-series autoregressive integrated moving average (ARIMA) model for forecasting (Box and Jenkins, 1976). Like any other such methods, it requires historical time series data on the variable under forecasting. It assumes that the future values of a time series have a clear and definite functional relationship with current and past values. The ARIMA offers a good method for production the magnitude of any variables (Kumar et al., 2009). The model has been tested in many forecasting. In fishery industries, ARIMA models as the most appropriate to forecast fishery landings in the Hellenic marine waters, since systematic biological time series data sets from explanatory

variables are lacking (Lloret et al., 2000). In financial forecasting, Fang combines two methods to develop the fuzzy ARIMA model based upon the works of time-series $ARIMA(p,d,q)$ model and fuzzy regression model. He uses the new method Fuzzy ARIMA to forecast the foreign market exchange and get the accurate forecasting value in a short time period (Tseng et al., 2001). ARIMA model and seasonal ARIMA methods to forecast primary energy demand on fossil fuel in Turkey starts in year 2020 (Ediger, 2006). ARIMA's model and neural network model to forecast the MSCI, Capital Market Index of United Stated America (Wood & Dasgupta, 1996). They found that the ARIMA model which was built on the percentage changes in 3-period moving average is performing better than the ARIMA model build on the index itself. The idea that Box and Jerkin's ARIMA model has predictability in many business activities including gold price is accepted in many researches in various countries. In Australia, the comparison between the forecasted London daily gold price resulted from Economic Research Center and ARIMA model has been done (Selvanathan, 1991). ARIMA model also used to forecast the primary energy demand in Turkey for the period 2007-2015 (Mucuk & Uysal, 2009). The ARIMA model can be utilized to forecast export value in Taiwan over the 2012-2015 (Arumugan et al., 2013). Additionally, Box-Jenkins' ARIMA is widely used to predict the future outcomes for economic or financial purposes. In this paper, we test the data of some major crops products in Bangladesh for relevant years. Specially, the data of some major crops product are employed to determine the best fit ARIMA model.

3. Research Objectives

The main objectives of the research are:

- To develop an appropriate time series model for forecasting foodgrain in Bangladesh.
- To check the accuracy of the existing results published by BBS.
- Analyze the different characteristics of a time series model.

4. Data and Methodology

Mainly the secondary data was used to prepare this research. The agricultural data of some selected foodgrain like rice product, wheat product, net total wheat, maize product from year 1972 to year 2006 was taken from Ministry of Food, Department of Agricultural Extension and Bureau of Statistics in Bangladesh. From these we used rice, wheat and maize as a variable of this research. Statistical Software R-version 3.02 is used for data entry and data analyzing purposes such as to test the stationary and non-stationary and fitting the appropriate ARIMA models. With this study, it is aimed to forecast some selected foodgrain in Bangladesh using the Box-Jenkins methodology used

in analysis and forecasting widely regarded to be the most efficient forecasting technique. We have some important theoretical models. These models can be classified into two categories such as univariate time series models which are stochastic process, Autoregressive process (AR), Moving Average process (MA), Autoregressive Moving Average process (ARMA), Autoregressive Integrated Moving Average process (ARIMA) (Gouriroux et al., 1997). The multivariate time series models are Vector Autoregressive process (VAR), Vector Autoregressive Moving Average process (VARIMA). The univariate process considered as stationary and non-stationary cases, where the latter are either integrated and so it can be made stationary by an appropriate level of differencing or is stationary around a deterministic polynomial of time. More generally, there are a number of reasons for forecasting on AR models. First, a focus of interest is the impact of interestedness on forecast ability. Finally, we can say that the forecasting of foodgrain in Bangladesh is necessary for a number of reasons such as to the best of our knowledge, this is the first known study of this kind for the Bangladesh foodgrain condition, it utilizes a unique daily data series, which were not utilized in previous studies. Also the results of this study will be of great interested both home and abroad. Finally, it may also be useful for interested in the development of capital markets in the emerging countries.

ARIMA Model: Time Series ARIMA model was proposed by Box-Jenkins in 1970, the model is denoted by $ARIMA(p, d, q)$, where *'p'* stands for the order of the autoregressive process,*'d'* is the order of the data stationary and *'q'* is the order of the moving average process to investigate the historical data and economic fluctuations (Wankhade et al., 2010). The algorithm is to be had as follows:

1) Data interpretation: The first step in developing a Box-Jenkins model is to decide if the series is stationary and if there is any significant seasonality that needs to be modeled. The autocorrelation functions (ACF) are used to define the distribution of sample data.

2) Model identification: Identifying the phase of the series by using autocorrelation function (ACF) and partial autocorrelation function (PACF).

3) Inference: The conditional likelihood and exact likelihood are used to estimate the parameters.

4) Diagnostic Checking: The process of diagnostic check involves testing the assumptions of the model to identify any areas where the model is inadequate. The statistical identification process includes whether the parameter achieves statistical significance or multicollinearity and whether the residual term is white noise or not. If the model is fund to be insufficient, it is necessary to remedy and repeat step (4) until a better model is identified (Arumugam et al., 2013). The Box-Jenkins method can be summarized with the chart reproduced in the following figure:

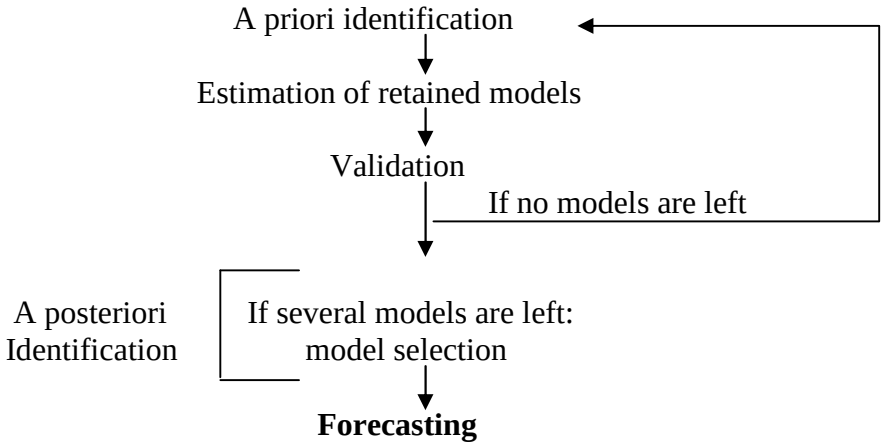

Figure-01: Scheme for the Box-Jenkins Method (Arumugam et al., 2013).

5. Research Findings

We compared forecasting performance between statistical and BBS's techniques. For forecasting, we used different foodgrain among these rice, wheat and maize production in Bangladesh. All of these foodgrain collected from 1972 to 2006 in different publications of Bangladesh.

5.1 Rice Production

5.1.1 Time Series Plot of the Rice Production

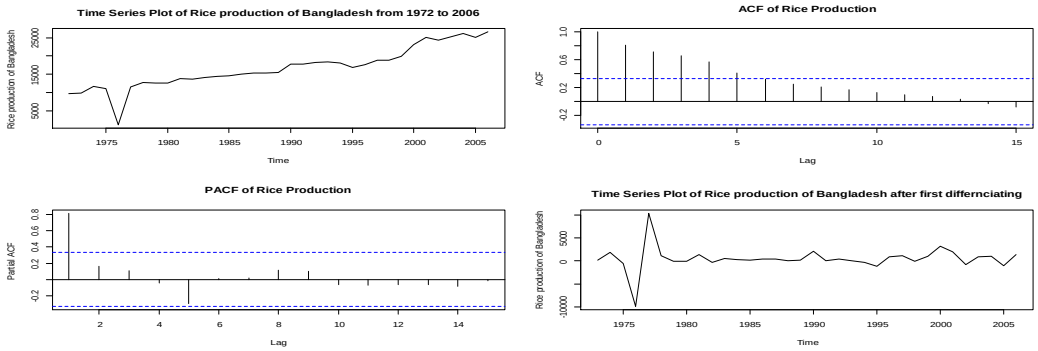

Figure-02: Time Series Plot of Rice Production from 1972 to 2006

Figure-02 shows that rice production data of Bangladesh seems to be trending. So the mean and variance are not stayed the same from time to time. Therefore from the time series plot we can see that the time series data is non-stationary. Also ACF and PACF of rice production show that autocorrelation coefficients at various lags are very high and declines slowly towards zero. Since the ACF curve of rice production exponentially decreasing, we conclude that the rice production follows autoregressive (AR) model. There are single large spike that are also insignificant spikes at different lags. All of this information the rice production of Bangladesh follows $ARIMA(1,1,0)$ model.

5.1.2 The selected Model for Rice Production

The estimated model is $x_t = 0.317\, x_{t-1} + 0.160$. the estimated σ^2 is 6321834, log-likelihood is -314.51 and also AIC is 633.02. The coefficient 0.317 indicates that the rice production increases 0.317 proportionately in the previous year from the present year. The selected model for rice production of forecasting is autoregressive moving average model.

5.1.3 Model diagnostic Checking for Rice Production

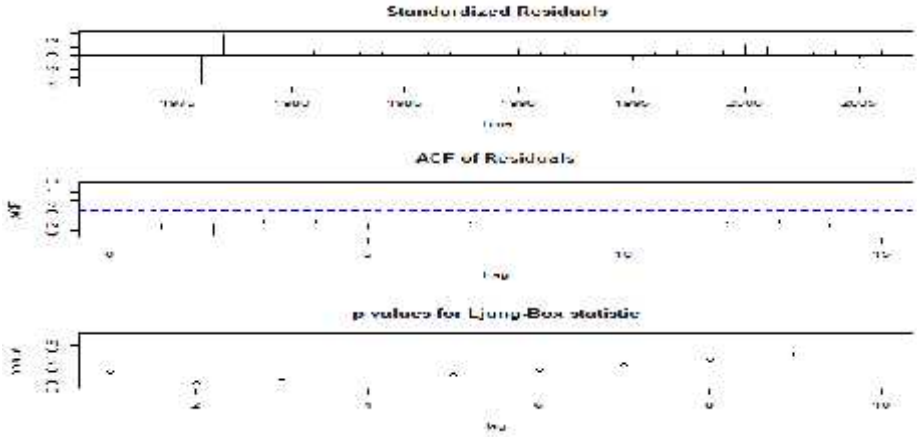

Figure-03: The diagnostic test of Rice Production of Bangladesh

The figure-03 shows that the residual of the proposed model follows white noise.

5.2 Wheat Production

5.2.1 Time Series Plot of Wheat Production of Bangladesh

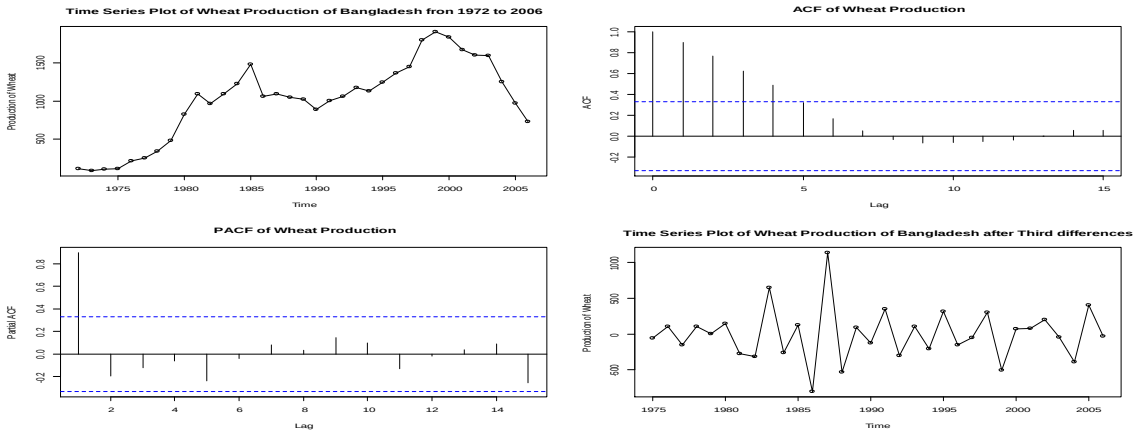

Figure-04: Time Series Plot of Wheat Production of Bangladesh

From figure-04, the wheat production data seems to be approximately trending. So it visuals that the mean and variance are not remain constant from time to time. Therefore from the time series plot we can see that the time series data is non-stationary. But the

ACF and PACF of wheat production of Bangladesh showed that the autocorrelation coefficients at various lags are very high and declines slowly towards zero. Since the ACF curve of wheat production exponentially decreasing, we conclude that the wheat production follows autoregressive (AR) model. There are single large spike that are also insignificant spikes at different lags. Considering all of this information the wheat production of Bangladesh follows $ARIMA(1,3,0)$ models.

5.2.2 The selected Model for Wheat Production

The estimated $ARIMA(1,3,0)$ model is, $x_t = 0.6457\, x_{t-1} + 0.1278$. The estimated σ^2 is 71231, log-likelihood is -224.45 and also AIC is 452.91. The coefficient 0.6457 indicates that the wheat production increases 0.6457 proportionately in the previous year from the present year.

5.2.3 Model diagnostic for Wheat Production

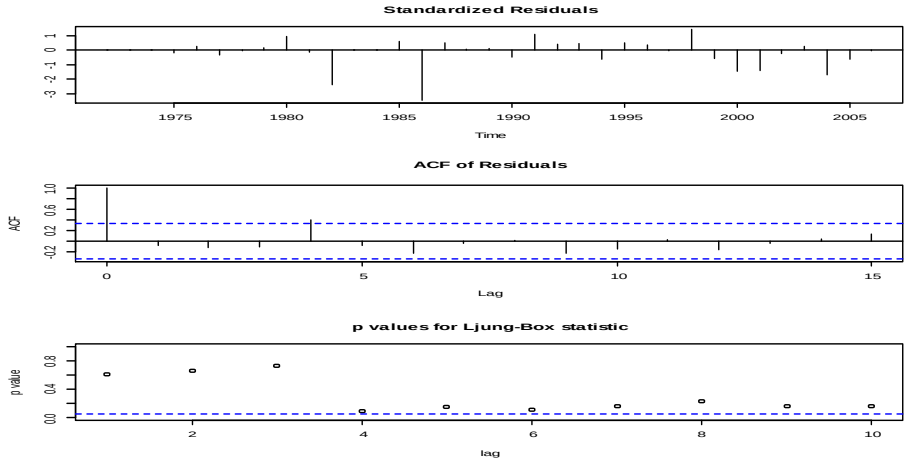

Figure-05: The diagnostic test of Wheat Production of Bangladesh

The Figure-05 shows that the residual of the proposed model follows white noise.

5.3 Maize Production

5.3.1 Time Series Plot of Maize Production of Bangladesh

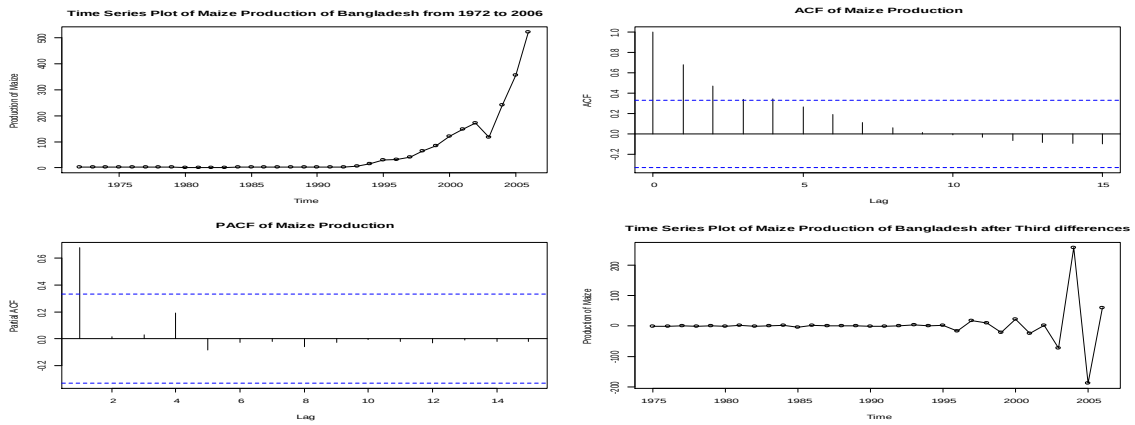

Figure-06: The diagnostic test of wheat Production of Bangladesh

Figure-06, maize production data of Bangladesh seems to be approximately trending. So the mean and variance are not remained constant from time to time. Therefore, the time series data is non-stationary and the ACF and PACF of wheat production of Bangladesh shown that autocorrelation coefficients at various lags are very high and declines slowly towards zero. Similarly as rice and wheat, ACF curve of rice production exponentially decreasing so wheat production follows autoregressive (AR) model. There are single large spike that are also insignificant spikes at different lags. As a result, the Maize production of Bangladesh follows $ARIMA(1,3,0)$ models.

5.3.2 The selected Model for Maize Production

The estimated $ARIMA(1,3,0)$ model is, $x_t = 0.7108 x_{t-1} + 0.1191$. The estimated σ^2 is 1688, Log-likelihood is -164.65 and also AIC is 333.31. The coefficient 0.7108 indicates that the Maize production increases 0.7108 proportionately in the previous year from the present year.

5.3.3 Model diagnostic checking for Maize Production

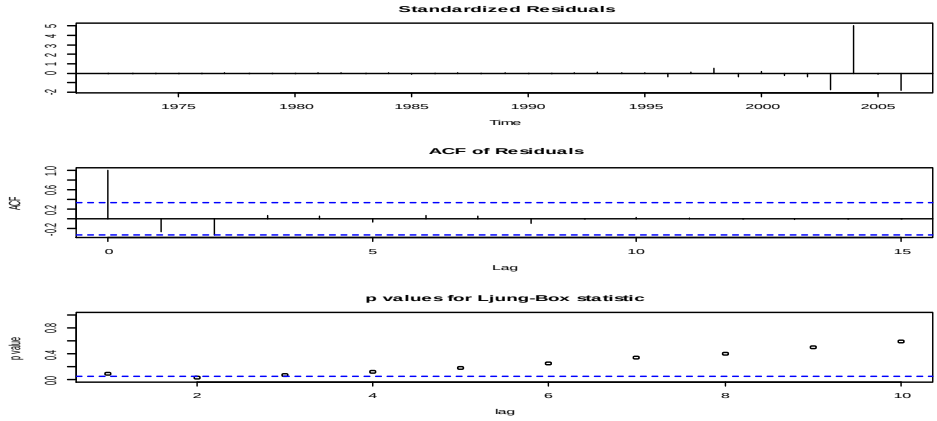

Figure-07: The diagnostic test of Maize Production of Bangladesh

The Figure-07 shows that the residual of the proposed model follows white noise.

5.4 Comparing forecasting values of foodgrain with BBS projection

The projected values of BBS and forecasting values of rice, wheat and maize production are mentioned in the table-01.

Table-01: The difference between projected, forecasting values from the actual values.

Foodgrain	Year	Projected values of BBS	Forecasting values by Proposed Model	Difference between Projected & Actual values	Difference between Forecasting & Actual values
Rice	2010	24519.60	26202.61	9022.40	7598.58
	2015	25943.42	27199.26	-	-
	2020	27632.14	27292.21	-	-
Wheat	2010	1600.00	618.45	628.00	353.55
	2015	1600.00	768.76	-	-
	2020	1600.00	986.19	-	-
Maize	2010	450.00	1403.55	568.28	385.27
	2015	550.00	1697.59	-	-
	2020	600.00	1948.06	-	-

** All are measured by Thousand Metric Tons.

** The actual values of rice production of Bangladesh in 2010 are 33542.00, wheat production 972.00 and maize production 1018.28.

**The actual values all of these variables are not published in 2015 and 2020. So we can't compare these two years.

The table-01 shows projected values of BBS in different years in the third column, forecasting values by proposed models in the fourth column, the difference between projected values of BBS and actual values in the fifth column and the difference between forecasting values using statistical models and actual values in the sixth column. The rice production of Bangladesh in 2010 is 33542.00 (000 metric tons). The table-01 shows the difference between projected and actual values of rice 9022.40 (000 metric tons) and the difference between forecasting values and actual values of rice 7598.58 (000 metric tons). For rice production, comparatively forecasted values of a proposed model are more closed to the actual value in 2010. Again, the table-01 shows that the wheat production in 2010 is 972.0 (000 metric tons), the difference between projected and actual values 628.00 (000 metric tons). Also the difference between forecasting and actual values of wheat production in 2010 is 353.55 (000 metric tons). Comparing these two differentiate values of wheat production, the forecasted value is more nearest to the actual value than projected values. Similarly, maize production of Bangladesh gives the same results. From

all of this information, the statistical methods give the better results comparatively BBS's techniques.

6. Conclusion

As a country, the important issue is to know foodgrain requirement and its implementation for future development. The Bangladesh Bureau of statistics (BBS) in this country has response to collect this information and publish to the public to aware of the people especially farmer and economists. Also the ministry of food and agriculture contribute to increase efficient of works in this sector and company. That's why we want to know how they forecast in different time. We chose different foodgrain and find which techniques are more accurate, BBS or statistical time series models. As for we have chosen ARIMA models in different orders as a statistical time series model for prediction. The forecasting result shows that the forecasting value is the nearest to the actual value in comparing with BBS's. This result is same for all variables like rice, wheat and maize. All of these information, we conclude that our predicted value is more accurate than BBS's. However, we do not neglect the forecasting values of the BBS or the ministry of food and ministry of agriculture but we suggest that the bureau of Bangladesh and other authors when they forecast they can use these models for gaining better forecasting.

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