ISSN 0973-8975

J.Mech.Cont. & Math. Sci., Vol.-7, No.-2, Januaryy (2013) Pages 1056-1066

FORECASTING PRODUCTION OF FOOD GRAIN USING ARIMA MODEL AND ITS REQUIREMENT IN BANGLADESH

By

[1]Lasker Ershad Ali, [2]Masudul Islam, [3]Md. Rashed Kabir and [4]Faruque Ahmed

[1]Mathematics Discipline, Khulna University, Khulna-9208, Bangladesh

[2]Statistics Discipline, Khulna University, Khulna-9208, Bangladesh

[3]Department of Mathematics, Pabna Science & Technology University, Bangladesh

[4]Department of Mathematics, Jahangir nagar University, Dhaka, Bangladesh

Abstract.

We forecast the food grain requirement and its production in Bangladesh. Before forecasting, we examine different methods and find time series model i.e. ARIMA model in different order predict accurate values. Then we used autoregressive integrated moving average (ARIMA) models to forecast the future amount of food grain in different years in this study. For the accuracy checking, we take the difference between the actual amount of food grain in a specific year and the predicted or the forecasting amount of the food grain in that year.

Keywords and phrases : forecast, food grain, production, ARIMA model

বিমূর্ত সার ***(Bengali version of the Abstract)***

বাংলাদেশে খাদ্যশস্যের প্রয়োজনীয়তা এবং ইহার উৎপাদন সর্ম্পকের আমরা পূর্বাভাস দিয়েছি । পূর্বাভাস দেওয়ার আগে আমরা বিভিন্ন পদ্ধতিকে পরীক্ষা করেছি এবং কালীন - সারি নির্ণয় করেছি । অর্থাৎ বিভিন্ন ক্রমের ক্ষেত্রে ARIMA মডেলটির সাহায্যে সঠিক মানের ভবিষ্যদ্বানী করেছি । এরপর আমরা স্ব-প্রতিগমন গতিশীল গড়কে (ARIMA) মডেলের সাহায্যে বিভিন্ন বছরে ভবিষ্যতে খাদ্যশস্য কত পরিমান লাগবে তার পূর্বাভাস প্রসঙ্গে বিচার বিবেচনা করেছি । সঠিকতা পরীক্ষার জন্য একটি নির্দ্দিষ্ট বছরে খাদ্যশস্যের বাস্তব পরিমান কত এবং সেই বছরেই খাদ্যশস্যের পরিমানের ভবিষ্যদ্বানী অথবা পূর্বাভাস কত ছিল তার পার্থক্যকে গ্রহণ করেছি ।

1. Introduction

Food is the strategic commodity of the economy and highest priority among the necessities of life. Now-a-days, the issue of food security is thus a burning question of the day. In Bangladesh, the land of production of food is very scarcity. Therefore, the authority of Bangladesh should take a right decision about food grain. Bangladesh Bureau of Statistics takes an important role of steps about how much amount of food grain required producing in Bangladesh. Thus, we have to insure that how they estimate of the future prediction of main food grain 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 food grain in any country is important. The production of food grain depends on the nature of the environment. The government should take a good decision to stock food grain in the future time. However, how much food grains take stock in the future? So, for this case we have to research about the food grain availability. The researcher needs some theoretical models to research about the food grain.

This paper applies Autoregressive Integrated Moving Average (ARIMA) forecasting model, the most popular and widely used forecasting models for univariate time series data. Although it is applied across various functional areas, it's application is very limited in agriculture, mainly due to unavailability of required data and also due to the fact that agricultural product depends typically on monsoon and other factors, which the model failed to incorporate. In this context, it is worth mentioning, few applications of ARIMA model for forecasting agriculture product. Applying ARIMA model Padhan(2012) forecasted annual productivity of selected 34 agricultural product in India with annual data from 1950 to 2010; Hossian *et al.* (2006) forecasted three different varieties of pulse prices namely motor, mash and mung in Bangladesh with monthly data from Jan

1998 to Dec 2000; Wankhade *et al.* (2010) forecasted pigeon pea production in India with annual data from 1950-1951 to 2007-2008; Saeed(2000) forecasted wheat production in Pakistan with annual data form 1947-48 to 1988-89; Shukla and Jharkharia(2011) forecasted Ahmedabad wholesale vegetable market in India; Khin *et al.* (2008) forecasted natural rubber price in world market; Shukla and Jharkharia (2011) forecasted wholesale vegetable market in Ahmedabad; Assis *et al.* (2010) forecasted cocoa bean prices in Malaysia along Nochai and Nochai (2006) forecasted palm oi in Thailand; Masuda and Goldsmith (2009) forecasted world Soybean productions; Cooray (2006) forecasted Sri Lanka's monthly total production of tea and paddy beyond Sept 1988 using monthly data from January 1988 to September 2004. With these exceptions, there is paucity of studies regarding applications of ARIMA model for forecasting agricultural products. Our main findings are as follows. Firstly, develop an appropriate model for forecasting time series and estimate the time series model for estimating amount of food

grain. Secondly, check the accuracy of the existing results published by BBS and finally, forecast the condition food requirement in Bangladesh in next five to ten years. The paper is organized as follows. Section 2 is devoted to some methods that we analysis of the data. Section 3 contains analysis of appropriate model selection of food grain with appropriate diagnosing checking. Section 4 discusses accuracy checking and comparative study of food grain. We summarize and conclude in Section 5.

2. Data description and Methods

The data is secondary data that is taken from Bangladesh Bureau of Statistics (BBS) online process and Dhaka office. The data is annual data included information from 1971 through 2006. The variables of this data are year, mid-year population, food grain requirement, rice wheat, maize production, net total, import/donation (rice and wheat). We use for this research as the population, food grain requirement, production of rice, wheat, maize, combine rice and wheat total.

One of time series models which is popular and mostly used in ARIMA model. ARIMA (p,d,q) model is a mixture of Autoregressive (AR) model which shows that there is a relation of a value in the present (Z) and value in the past (Z_{t-k}), added by random value and Moving average (MA) model which shows that there is a relation between a value in the present (Z_t) and residuals in the past $(Z_{t-k},\ k=1,2...)$ with a non-stationary data pattern and d differencing order. The form of ARIMA (p,d,q) is:

$$\Phi_p(B)(1-B)^d Z_t = \theta_q(B)a_t \qquad (1)$$

where, p is AR model order, q is MA model order, d is differencing order and:

$$\Phi_p(B) = (1-\Phi_1 B - \Phi_2 B^2 - ... - \Phi_p B^p)$$
$$\theta_q(B) = (1-\theta_1 B - \theta_2 B^2 - ... - \theta_q B^q)$$

Generalization of ARIMA model for a seasonal patter data, which is written as:

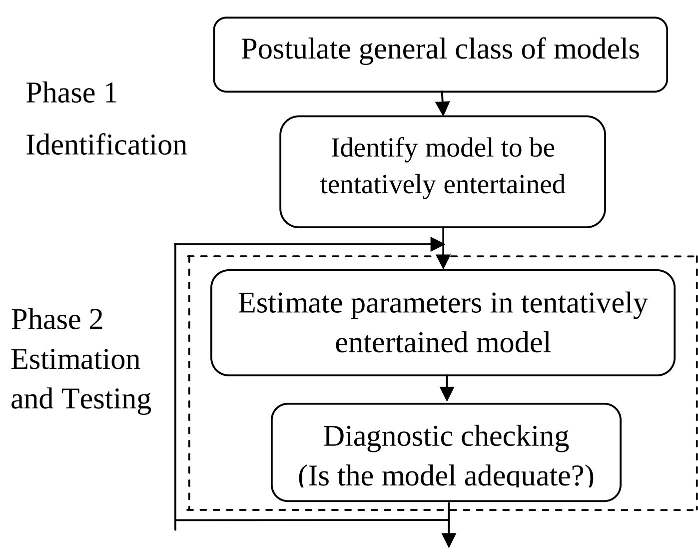
$$ARIMA(p,d,q)(P,D,Q)^2 = \Phi_p(B)\Phi_p(B^2)(1-B)^2(1-B^s)^D = Z_t\theta_q(B)^{\Theta}Q(B^s)a_t \qquad (2)$$

where, s is seasonal period.

$$\Phi_p(B^s) = (1-\Phi_1 B - \Phi_2 B^2 - ... - \Phi_p B^p)$$
$$\theta_p(B) = (1-\theta_1 B - \theta_2 B^2 - ... - \theta_q B^q)$$

Box and Jenkins (1970) have proposed a general forecasting method for univariate series,

such a method is based on ARIMA processes.



Phase 3
Application

Use model to forecast

Fig. 1 Scheme for the Box-Jenkins Method

3. Model Selection and diagnosing checking

This section presents analysis for ARIMA model building. The preliminary understating about the nature of data showed that there is no consistency in the output of all these variables over the period (Fig. 2).

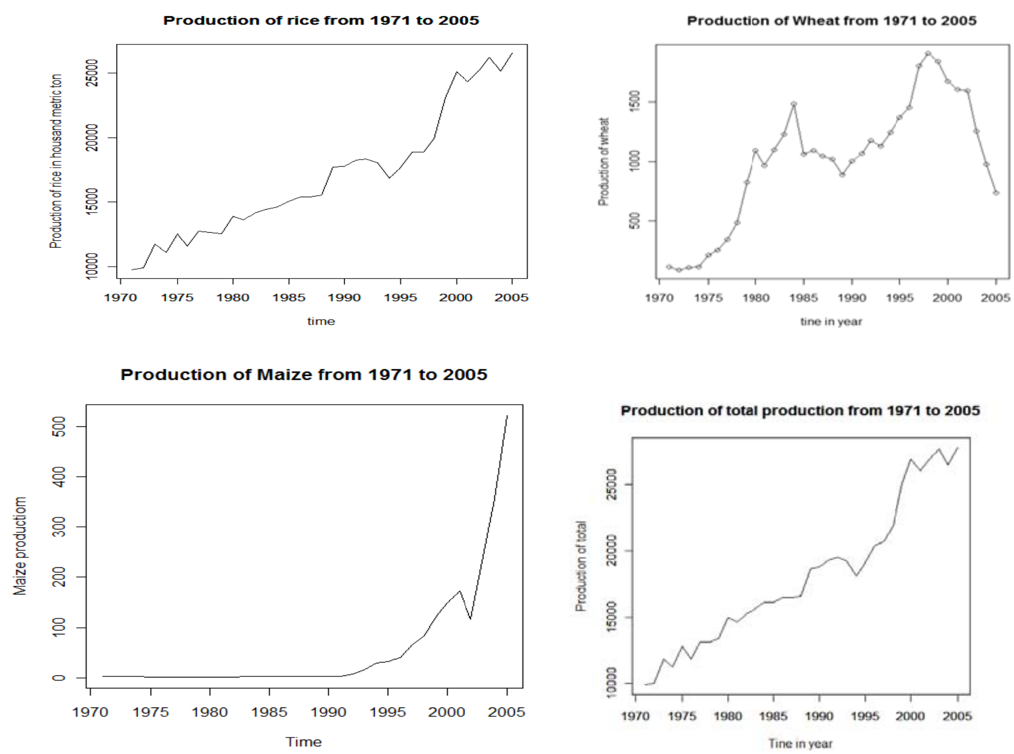
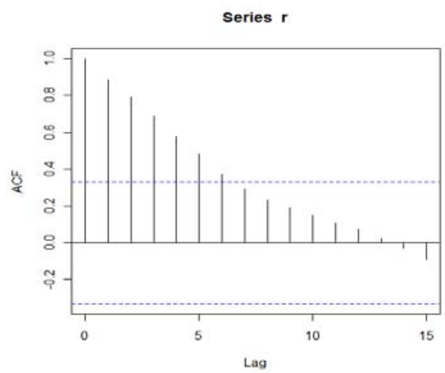
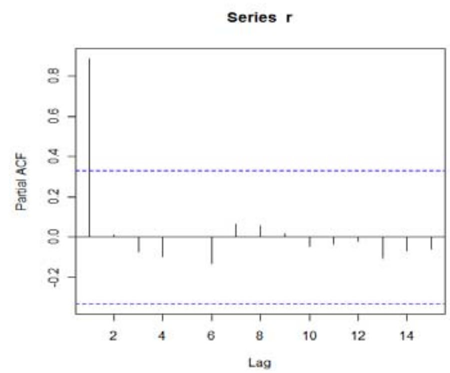
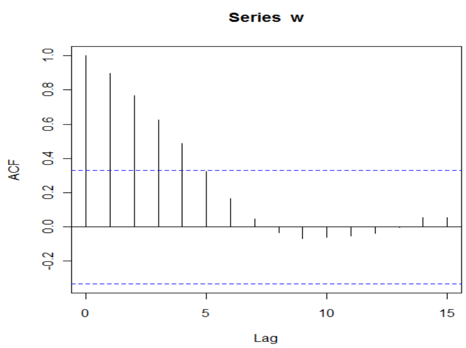


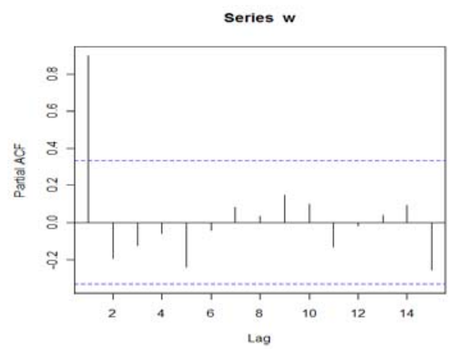
Fig. 2 Time series plot of selected agricultural products

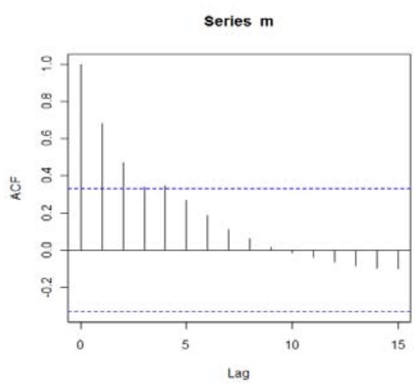
The output of some variables shows increasing trends, although nonlinear and others provide mixed evidences. In time series language most of the variables are non-stationary in nature; hence their mean and variance are not-constant and time variant.

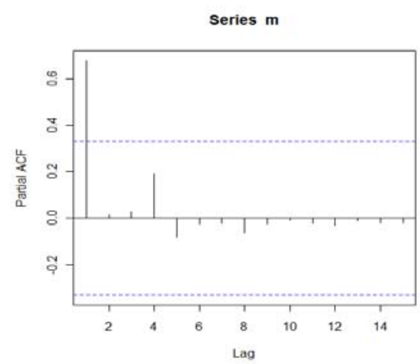

Series r
ACF
Lag


Series r
Partial ACF
Lag


Series w
ACF
Lag


Series w
Partial ACF
Lag


Series m
ACF
Lag


Series m
Partial ACF
Lag

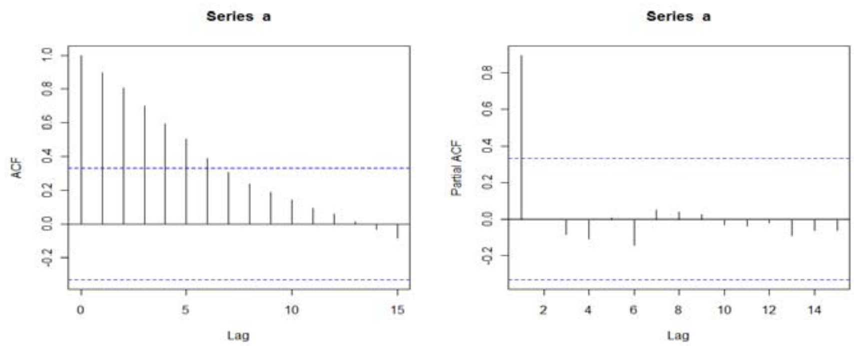


Fig. 3 ACF & PACF plot's of selected agricultural products

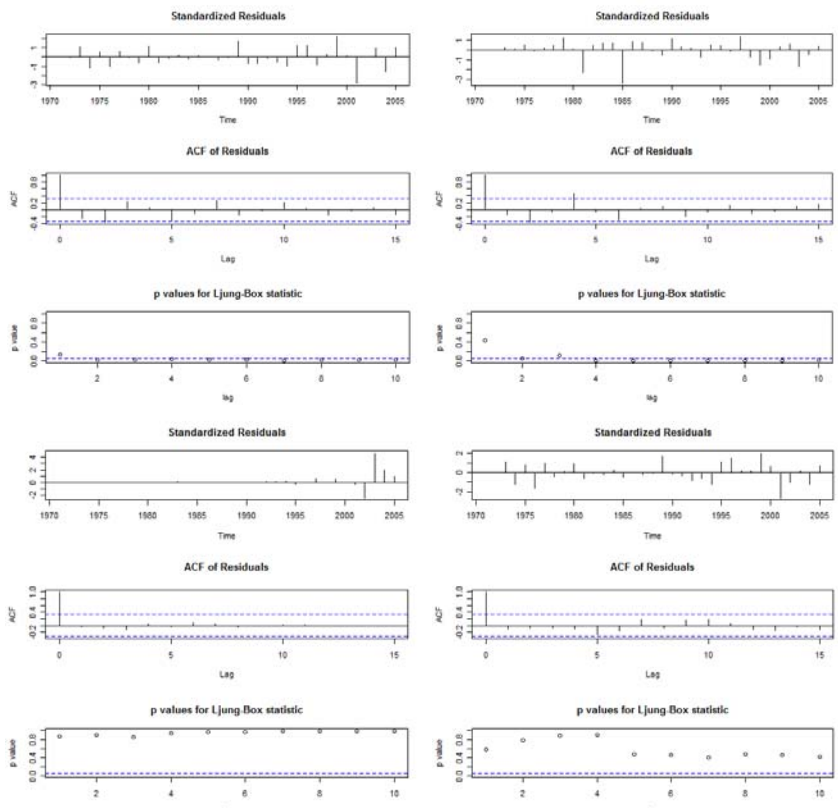


Fig. 4 Diagnostic test of selected agricultural products

Agricultural	**Estimated Model**
Rice	$X_t = u_t + 0.049 X_{t-1}$
Wheat	$X_t = u_t + 0.3022 X_{t-1}$
Maize	$X_t = u_t - 0.3557 X_{t-1} + 0.0921 X_{t-2}$
Total food grain	$X_t = u_t + .8378 X_{t-1} - 0.434 X_{t-2}$

The ACF and PACF curve of the rice production exponentially decreasing with order one. So, the rice production follows autoregressive model with order one. After first difference the data become stationary. Therefore, the rice production from 1971 to 2005 follows ARIMA $(1,1,0)$ model. Similarly for other's ACF and PACF curve shows that for wheat production gradually decreasing and follows AR(1) model and second difference follows stationary process means wheat production follows ARIMA $(1,2,0)$ model, the maize production follows autoregressive process of order two and second difference of the maize production follows stationary process. Then maize production from 1971 to 2005 follows ARIMA$(2,2,0)$ model. Similarly, total food grain production from 1971 to 2005 follows ARIMA$(2,2,0)$ model (Fig.3).The estimated models are:

The standardized residual plot lies between the interval that means not lies outside of the range for all agricultural products. The ACF of the residuals, the p-value for the Ljung-Box statistic indicates that residual of all agricultural products follows white noise, show normality and the model is a good fit.

4. Comparative Study and Accuracy Checking

Considering 1971 to 2005 time period and require knowledge of every production as year 2010.Using the 'R' programming language, the estimated value as 29647.69 (000,M tons) and the actual value of production of rice in 2010 is 33542 (000, M tons). The difference between the actual and forecasting value in 2010 is more than the difference between the actual and the estimated value in 2010 which

Table 1: Comparative values in the BBS and our estimated values

	Rice	wheat	Maize	Total Production	Food grain Requirem
Production of rice in 2010	33542.	972.0	1018.3	35532.28	26377.1
Forecasting value in BBS	29150.	1600.	450.00	31200.00	27632.1
Estimated value in 2010	29647.	630.9	1290.2	28862.39	24155.3
Difference between forecasting and actual	4392.0 0	-628.0	568.28	4332.28	- 1255.00
Difference between estimated and actual value	3894.3 1	341.1	- 271.91	6669.89	2221.84

*All the estimated values are measured by the thousand metric tons (000, M. tons)

indicates our estimated value is more accurate than the forecasted value in BBS. Therefore, we conclude that our selected model is more appropriate than BBS and gives better forecast. Similarly, the model for wheat and maize gives more appropriate forecast than BBS but the model for total production, the forecasting values in BBS are more accurate than our predicted values. Then we consider the model for food grain requirement which indicates better forecast than BBS. Finally, we conclude that our forecasting model gives better forecast and more accurate. Now, we forecast next five and ten years of our data as below.

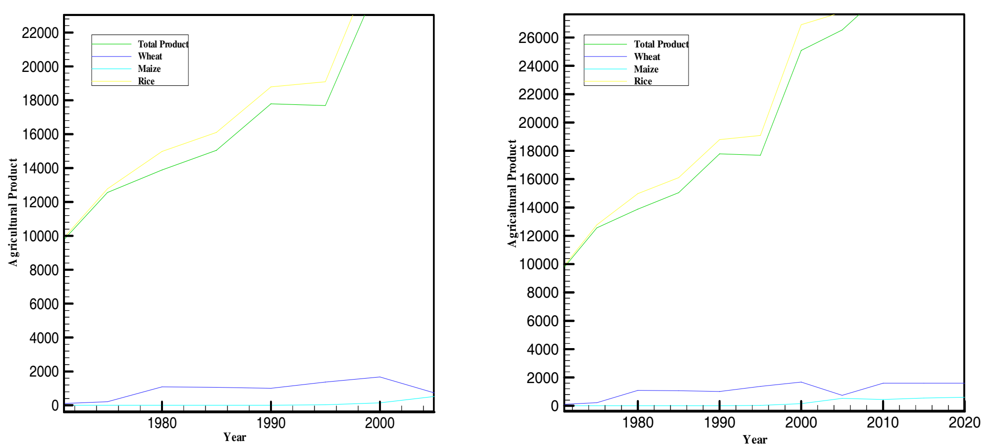


Fig. 5 Actual Versus forecasted value agricultural products

5. Conclusions

Forecasting is an important problem that spans many fields including business and industry, government, economics, environmental sciences, medicine, social science, politics and finance. The reason that forecasting is so important for prediction of future events, is a critical input into many types of planning and decision making. Bangladesh Bureau of Statistics (BBS) in our country response to collect this information and publish to the public. The Ministry of food and the Agricultural Ministry also contribute this sector. In this study, we conducted the experiment which involves ARIMA model in different order predict accurate values for different agriculture products. Because, all of these predicted values are more nearest to the actual values and some of the forecasting values are the more nearest to the actual values. However, we do not neglect the forecasting values of the BBS or the ministry of food and ministry of agricultural. But our analysis gives better forecasting result than BBS.

References

1) Assis, K., Amran, A., Remali, Y. and Affendy, H. (2010). A comparison of univariate time series methods for forecasting cocoa bean prices. *Trends Agric. Econ*., 3, 207–215.

2) Brokwell, P. J. & Davis, R. A. (1997). *Introduction to Time Series and Forecasting*, Springer, New York.

3) Cooray, T.M.J.A.(2006). Statistical analysis and forecasting of main agriculture output of Sri Lanka: rule-based approach. *Appeared In 10th International Symposium*, 221, 1–9. Sabaragamuwa University of Sri Lanka.

4) Clements, M. and Hendry, D. (1998). *Forecasting economic time series*, United University Press, Cambridge.

5) Gourieroux, C. and Monfort, A.(1997).*Time Series and dynamic Models*, Cambridge University Press, England.

6) Gujarati, D. N.(2004). *Basic Econometrics*, 4th ed., McGraw Hill, New York.

7) Hossain, M.Z., Samad, Q.A. & Ali, M.Z. (2006). ARIMA model and forecasting with three types of pulse prices in Bangladesh: A case study. *International Journal of Social Economies*. 33, 344–353.

8) Jonathan, D. C. & Kung-Sik, C.() *Time Series Analysis with Application in R* , 2nd ed., Spring Steet, New York.

9) Saeed N., Saeed A., Zakria M. & Bajwa, T. M. (2000). Forecasting of Wheat Production in Pakistan using Arima Models, *International Journal of Agriculture & Biology*, 1560–8530, 02,4,352–353.

10) Makridakis, S.(2003). *Forecasting Method and Application*, 3rd ed., John Wiley and Sons, New York.

11) Montgomery, D. C.(1990). *Forecasting and Time Series Analysis*", 2nd ed., McGRAW-Hill, Inc, New York.

12) Nochai, R. & Nochai, T. (2006). *ARIMA Model for Forecasting Oil Palm Price: 2nd IMT-GT Regional Conference on Mathematics, Statistic and Applications*. University Sains Malaysia, Penang, June 13-15.

13) Prindyck, R. S. & Rubinfeld, D. L. (1981). *Economic Models and Economic Forecasts*, 3rd ed., McGrsw-Hill, Inc, New York.

14) Shukla, M. & S. Jharkharia.(2011). Applicability of ARIMA models in wholesale vegetable market: An investigation. *Proceedings of the 2011 International Conference on Industrial Engineering and Operations Management.* Kuala Lumpur, Malaysia, January 22-24.

15) Wankhade, R., Mahalle, S., Gajbhiye, S. & Bodade, V.M. (2010). Use of the ARIMA model for forecasting pigeon pea production in India. *International Review Of Business Finance*, 2, 97–102.

16) Thorne, B. & Carlson W. (2007). *Statistics for Business and Economics*, 6th ed., Arrangement with Pearson Education, Inc. and Dorling Kindersley publishing, Inc., New Delhi.