International Journal of Agricultural Management & Development (IJAMAD)
Available online on: www.ijamad.com
ISSN: 2159-5852 (Print)
ISSN:2159-5860 (Online)

Forecasting Milled Rice Production in Ghana Using Box-Jenkins Approach

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Received: 10 August 2011,
Accepted: 12 November 2011

Abstract

The increasing demand for rice in Ghana has been a major concern to the government and other stakeholders. Recent concerns by the coalition for African Rice Development (CARD) to double rice production within ten years in Sub-Saharan countries have triggered the to implement strategies to boost rice production in the government. To fulfill this requirement, there is a need to monitor and forecast trends of rice production in the country. This study employs the Box-Jenkins approach to model milled rice production using time series data from 1960 to 2010. The analysis revealed that ARIMA (2, 1, 0) was the best model for forecasting milled rice production. Although, a ten years forecast with the model shows an increasing trend in production, the forecast value at 2015 (283.16 thousand metric tons) was not good enough to compare with the current production of Nigeria (2700 thousand metric tons), the leading producer of rice of rice in West Africa.

Keywords:
Box- Jenkins, Milled rice, Production, Forecasting, Ghana

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INTRODUCTION

Rice (*Oryza sativa*) is one of the most important cereal crops and feeds more than a third of the world's population (Khush, 1997). The cereal plays a major role in contributing to agricultural GDP (Gross Domestic Product) and the economy of Ghana. The increase in per capital consumption of rice in recent times outstrips its supply in the country. The government imports up to 200% of local production in order to compensate for the short fall in supply (Dogbe, 1996). The country spends US$450 million annually on rice imports to fill this gap in rice production (FAO, 2011).

Nowadays, rice as a staple food in Ghana is confronted with several challenges in terms of production. For instance, the unbridled trade liberalization has made the country a net importer of rice. Furthermore, total land area for rice production, illiteracy rates, low yield, poor storage facilities, pest and diseases and poor market price for farmers have been attributed to low rice production in Ghana (Seidu, 2008).

Recent concerns by the Coalition for African Rice Development (CARD) to help Sub-Saharan African countries to double rice production within ten years have triggered the government and the Ministry of Food and Agricultural (MoFA) to implement strategies to boost rice production in Ghana. In response to this, the country has set a target of being the leading producer of rice in West Africa by 2015. This has led to the establishment of the Fievie Rice Projects in the Volta Region of the country. The project aims to produce highest rice grade qualities on 4,000 hectares of land (www.allAfrica.com).

The steps taken by the country to meet the increasing demand and to be the leading producer of rice in West Africa is cogent. But to fulfill this goal there is a need to monitor trends of production in the country.

Myriads of researches on forecasting have been done using the Box-Jenkins (1976) stochastic Autoregressive Integrated Moving Average (ARIMA) model. Badmus and Ariyo (2011), forecasted area of cultivation and production of maize in Nigeria using ARIMA model. They estimated ARIMA (1, 1, 1) and ARIMA (2, 1, 2) for cultivation area and production of maize respectively. Najeeb *et al.*, (2005), employed Box-Jenkins model to forecast wheat area and production in Pakistan. Their study showed that ARIMA (1, 1, 1) and ARIMA (2, 1, 2) were the appropriate models for wheat area and production respectively. Falak and Eatzaz (2008) analyzed future prospects of wheat production in Pakistan. They obtained the parameters of their forecasting model using Cobb-Douglas production function for wheat, while future values of various inputs are obtained as dynamic forecasts on the basis of separate ARIMA estimates for each input and for each Province. Rachana *et al*., (2010), used ARIMA model to forecast pigeon pea production in India. The Box- Jenkins methodology have been used by a number of researchers to forecast future demands in terms of internal consumption and export to adopt appropriate measures (Muhammad *et al*., 1992, Shabur and Haque, 1993, Sohail *et al*., 1994).

Thus in this study, the Box-Jenkins approach was used to model and forecast milled rice production in Ghana.

MATERIALS AND METHODS

This study was carried out on the basis of milled rice production data from the period 1960 to 2010 collected from secondary sources, (Index mundi, 2011). The data was model using Autoregressive Integrated Moving Average (ARIMA) stochastic model popularized by Box-Jenkins (1976). An ARIMA (p, d, q) model is a combination of Autoregressive (AR) which shows that there is a relationship between present and past values, a random value and a Moving Average (MA) model which shows that the present value has something to do with the past residuals. The ARIMA process can be defined as:

$$Ø (B) (\Delta^d y_t - \mu) = \theta (B) e_t$$

Where:

y_t = represents rice production in thousand metric tons.

μ = Mean of $\Delta^d y_t$,

$$Ø (B) = 1- Ø B - \dots - Ø_p B^p$$

$$\theta (B) = 1- Ø B - \dots - Ø_q B^q$$

$\O_t$ = The i^{th} autoregressive parameter

θ_t = The i^{th} moving average parameter

p, q and *p*denote the autoregressive, moving average and differenced order parameter of the process respectively.

Δ and *B* denote the difference and backward shift operators respectively.

The estimation of the model consists of three steps, namely: identification, estimation of parameters and diagnostic checking.

Identification step:

Identification step involves the use of the techniques to determine the values of *p, q* and *d*. The values are determined by using Autocorrelation function (ACF) and Partial Autocorrelation function (PACF). For any ARIMA (*p, q, p*) process, the theoretical PACF has non-zero partial autocorrelations at lags 1, 2,..., *p* and has zero partial autocorrelations at all lags, while the theoretical ACF has non zero autocorrelation at lags 1, 2,…, *q* and zero autocorrelations at all lags. The non-zero lags of the sample PACF and ACF are tentatively accepted as the *p* and *q* parameters. For a non stationary series the data is differenced to make the series stationary. The number of times the series is differenced determines the order of *d*.

Estimation of parameters:

The second step is the estimation of the model parameters for the tentative models that have been selected.

Diagnostic checking:

The estimated model must be check to verify if it adequately represents the series. Diagnostic checks are performed on the residuals to see if they are randomly and normally distributed. Here, the Anderson-Darling test for normality was used. Also, the residual plot versus the fitted values was used to check if the residuals are randomly scattered. An overall check of the model adequacy was made using the Ljung-Box **Q** statistics. The test statistics is given by:

$$Q_m = n(n+2)\sum_{k=1}^{n}(n-k)^{-1}r_k^2 \approx \chi^2_{m-r}$$

where

r_k^2 = the residuals autocorrelation at lag *k*

n = the number of residuals

m = the number of time lags included in the test.

When the *p*-value associated with the **Q** is large the model is considered adequate, else the whole estimation process has to start again in order to get the most adequate model.

RESULTS AND DISCUSSION

The maximum milled rice production was 295 thousand metric tons in 2010 and the minimum was 21 thousand metric tons which occurred in 1960, 1962 and 1965. The average milled rice production was 85.02 thousand metric tons. The increasing trend in the time series plot (Figure 1) of milled rice production showed that the series was not stationary. The gradual decay in the ACF (Figure 2) and very dominant PACF (Figure 3) at lag one indicate that the data was not stationary. To stabilize the variance and achieve a stationary mean, the data was logarithmic transformed and differenced. The first order difference was enough to make the data stationary. Therefore ARIMA (*p, 1, q*) could be identified. The alternating positive and negative ACF suggests an autoregressive process. (Figure 5) Using the PACF with a significant spike at lag 2, ARIMA (2, 1, 0) was identified (Figure 4). Table 1, shows the estimates of the ARIMA (2, 1, 0) model.

In order to make sure that this model is a representative of the data and could be used to forecast future milled rice production, the ACF and PACF for the residuals of the fitted model were examined. As shown in Figure 6, it was clear that no pattern was observed in

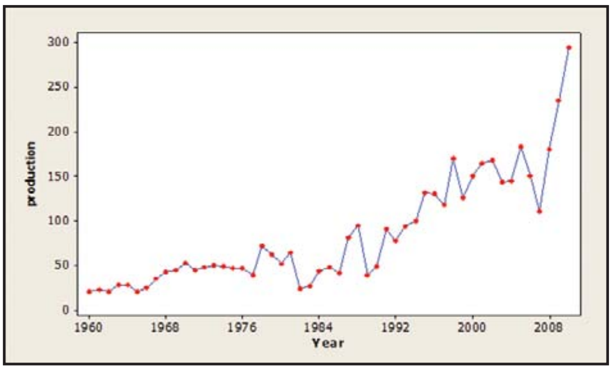

Figure 1: Time series plot of milled rice production

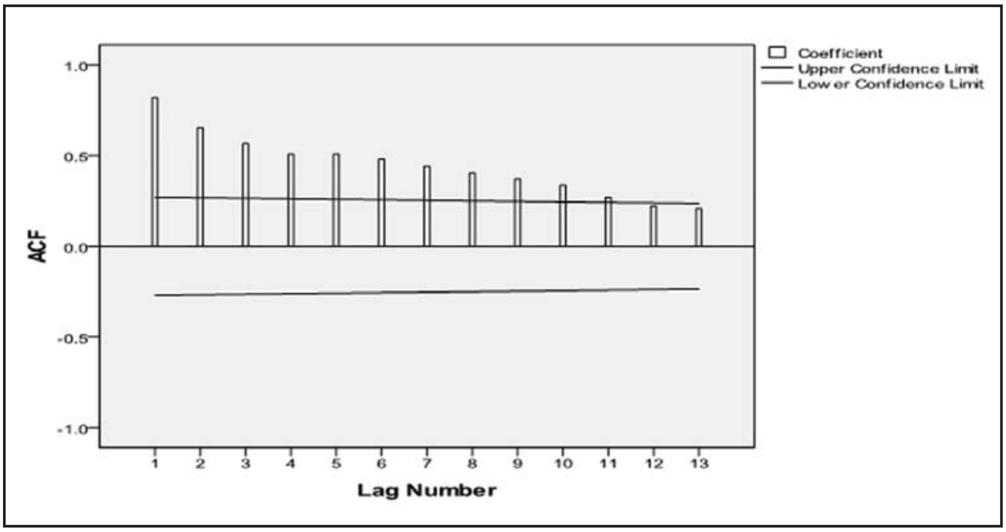

Figure 2: Plot of ACF for milled rice production

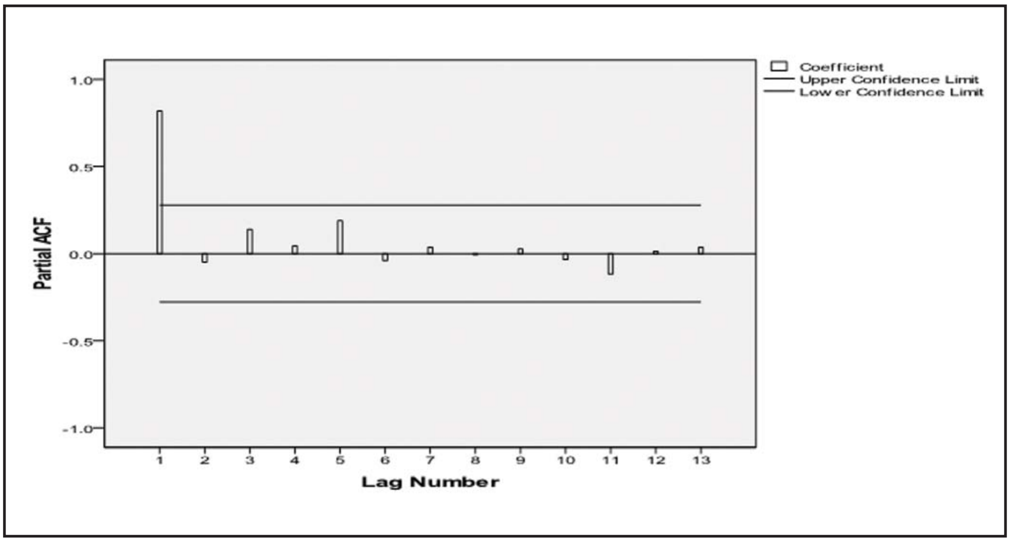

Figure 3: Plot of PACF for milled rice production

Table1: Estimates of ARIMA (2, 1, 0) model

Type	Coefficient	SE	t-value
AR (1)	-0.244	0.135	-1.809
AR (2)	-0.370	0.136	-2.731

the residuals. Thus, the model could be used to represent the milled rice production data. Also, the Ljung-Box statistics was large indicating the model was adequate. The plot of the residuals against the fitted values showed scattered trend, therefore the model was fitted properly. For normality, the Anderson-Darling test was used and the assumption of normality was accepted. Since the residuals were normally distributed the model was fitted properly.

Finally, ARIMA (2, 1, 0) model for milled rice production was used for ten years forecast. The forecast are shown in Table 2 at 95% confidence interval. From Table 2, the forecast for the years

Table 2: Forecast for milled rice production

RICE PRODUCTION (000 metric tons)			
Year	Forecast	UCL	LCL
2011-2012	264.81	453.01	141.72
2012-2013	258.10	500.81	116.65
2013-2014	278.51	560.39	119.39
2014-2015	283.16	606.24	110.57
2015-2016	281.55	645.93	98.65
2016-2017	287.58	692.57	93.08
2017-2018	294.24	740.16	88.50
2018-2019	297.93	783.69	82.90
2019-2020	302.24	828.25	78.13
2020-2021	307.65	874.91	74.26

Note: UCL= Upper Confidence Limit and LCL= Lower Confidence Limit

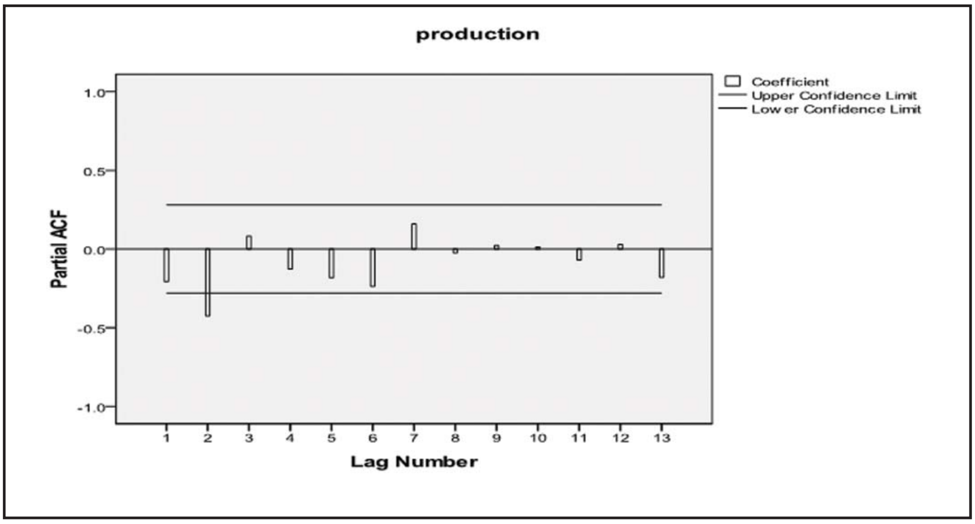

Figure 4: PACF plot for the differenced data

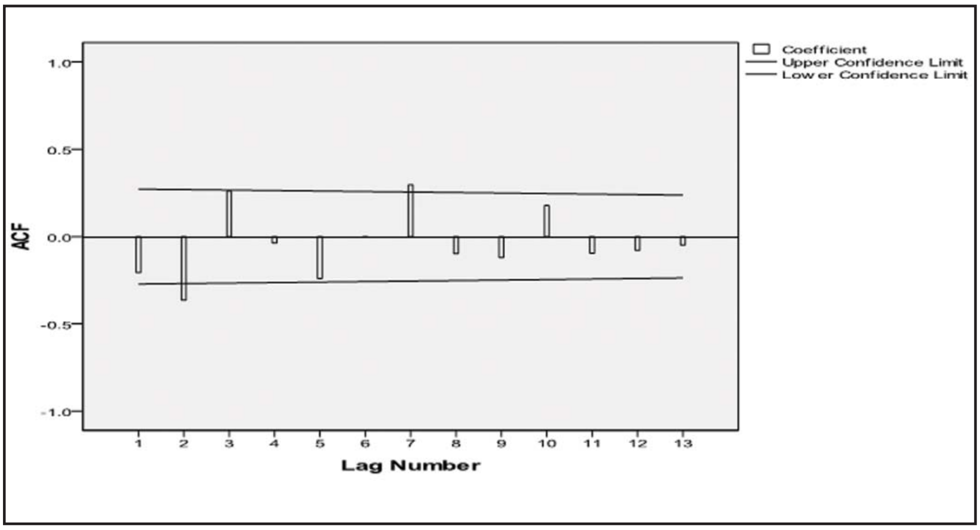

Figure 5: ACF plot for the differenced data

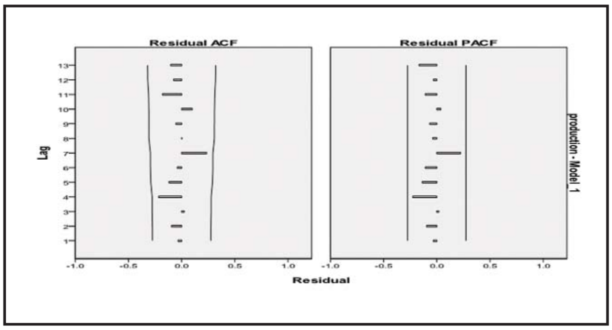

Figure 6: ACF and PACF plot of residuals

2011-2012 was 264.18 thousand metric tons with a 95% confidence limit of (141.72, 453.01) thousand metric tons. It was found that if government policies are not well improved, then the total milled rice production in the year 2020-2021 would be 307.65 thousand metric tons with a 95% confidence limit of (74.26, 874.91) thousand metric tons.

CONCLUSION

Although the forecast shows an increasing trend in milled rice production, this is not good enough to achieve the 2015 target of being the leading producer of rice in West Africa as the forecast (283.16 thousand metric tons) at that period is not appreciative compared to the total milled rice production of Nigeria (2700 thousand metric tons) currently, which is the leading producer of rice in West Africa.

To overcome the challenge, government has to increase the funds invested in rice production, motivate rice farmers and ensure that better land tenure system and conservative measures of rice farm lands are adopted.

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