ON THE FORECAST OF CEREALS PRODUCTION IN NIGERIA

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S. B. Akanni and O. I. Adeniyi*
Department of Statistics, University of Ilorin, Ilorin, Kwara State, Nigeria
*Corresponding author: adeniyi.oi@unilorin.edu.ng

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Abstract: The cereals production (CP) of Nigeria have great potentials that can contribute significantly to economic growth if well harnessed. The main goal of forecasting Time Series variable(s) is to improve productivity; which will in turn lead to increase in realizations. In this study, the CP was studied using the Box-Jenkins (1976) Methodology technically known as ARIMA modeling to model and forecast the series for the period of 2017 to 2026. The results showed that there was an upward trend albeit with fluctuations and the 1st difference of the series was stationary, meaning that the series was $I(1)$. Base on the AIC and BIC selection criteria, the best model that explains the series was found to be ARIMA (1, 1, 1). Residual diagnosis of the model confirmed that the error was white noise, no correlation found and forecast of 10 years terms was made which indicates that the series will continue to increase with these forecasted time period.

Keywords: Forecast, ARIMA, Box-Jenkins, cereal production, AIC, BIC

Introduction

Cereals (*Poaceae*) are edible parts of grains such as rye, oats, barley, maize, triticale, millet and sorghum. More than 50% of world daily caloric intake is derived from cereal grain consumption (Awika *et al.*, 2011). Cereals are the major dietary energy supplies and provide significant amount of protein, minerals (potassium and calcium) and vitamins (vitamins A and C) (Idem and Showemimo, 2004). They (cereals) come in many different forms, and each form has popularity in different countries. The major cereal crops in Nigeria are rice, maize, sorghum, wheat, pearl, millet, sugar cane and fonio millet with rice ranking as the sixth major crop in terms of the land area while sorghum account for 50% of the total cereal production and occupies about 45% of the total land area devoted to cereal production in Nigeria (national extension agricultural research and liaison station (NEARLS, 1996).

Maize is the third most important cereal crop after wheat and rice, providing food for humans and animals and serving as a basic raw material for the production of starch, alcoholic beverages, food sweeteners and fuel (FAO, 2007). Maize is a major food crop grown in diverse agro ecological zones and farming systems and consumed by people with varying food preferences and socio-economic backgrounds in Nigeria. The demand for maize sometimes outstrips supply as a result of the various domestic uses (Akande, 1994). The crop is grown mainly in North East, North West and North Central of Nigeria and grown sparsely in South West, South East and South South of Nigeria. The central role of maize as a staple food is comparable to what rice is in Asia. Maize accounts for almost half of the calories and protein consumed in Nigeria and one-fifth of calories and protein consumed in West Africa. Maize occupies more than 1.5 million ha in Nigeria with an average yield of 1.5t – 2.0t per hectare under rain fed program. Considering the low average yield that are still pervasive in farmers' fields, meeting the projected increase demand for maize grain in Nigeria present a challenge.

Sorghum (*Sorghum bicolar*) ranks fifth in the world after wheat, rice, maize and barley (Dogget, 1988). Sorghum is the second most important cereal crop in Nigeria after maize with about 21% of total cereal area followed by millet which is about 14.2% of total cereal land coverage. Maize and sorghum can be malted and used for the production of traditional beer for weaning food (Reichert, 1982). The demand in sorghum and millet in Nigeria over the last twenty years reflected in the trend for increasing area under cultivation. Unfortunately however, crop productivity has not kept pace with increasing demand, due mainly to a lag in crop improvement efforts in sorghum and millet, relative to other cereals. Other factors are extreme environmental conditions, resource constrained and low farming input system.

Rice has become a highly strategic and priority commodity for food security in Nigeria. Consumption is growing faster than that of any other major staple in the country because of population increase, rapid urbanization and change in dietary intake. Although local rice production increased rapidly after the food crisis of 2008-2009, a key problem facing the rice sector in Nigeria is that local production has never caught up with demand. The country therefore continues to rely on importation to meet its increasing demand for rice. However recently, in 2016, the Government of Nigeria has restricted rice importation in order to encourage local production; one major problem is the smuggling practices of traders. Another major problem is the processing procedure that requires improvement to eliminate pebbles and stones in packaged local rice. Another important cereals crop; which is becoming popular in Nigeria is the wheat. Wheat production is holding steady at about 100,000 tons per year, despite heavy investment by the federal government to promote this cereal.

Sugarcane is also another important cereals crop that can be found in Nigeria. In some West African countries like Nigeria, Sugarcane (*Saccharum officinarum*) can be cultivated almost in all the states locally but commercially it is produced in: Kastina, Taraba, Kano, Adamawa, Jigawa, Kaduna, Kebbi, and Sokoto State. It is a perennial, tall grass, which looks like a bamboo cane and grows well in tropical areas (warm temperate).

It is argued that the over-dependence on oil has not allowed Nigeria to harness its potentials of agriculture (Ismaila *et al.*, 2010). Informed players in the industry have stated that the Middle Belt of Nigeria alone can supply the rice requirement of the whole of West Africa if supported with good, consistent and lasting government policies favouring agriculture. In Nigeria low yield of cereals is ascribed to increase cost of production, lack of fertilizers, non-maintenance of irrigation facilities and lack of labour. Management practices such as weeding, transplanting and harvesting place heavy demands on family labour which is always limited. The farm level input use efficiency is generally low among resource poor farmers.

In recent years a number of related formal models have been formulated to forecast some selected cereals such as maize, sorghum etc. In this study, we are applying the univariate time series model to justify truly whether past values of Nigeria Cereals Production (CP) series can predict its current and future values using (Box, 1976) methodology technically known as ARIMA modeling. The purpose of applying this fundamental approach in this study is to identify how to improve on cereals production for local and international consumptions.

Many researchers have conducted various researches on cereals production using different techniques. For instance, Kotra and Sheik (2016) forecasted the Rabi cereals production in Andhra Paresh of India using ARIMA (2, 1, 1) model. The model was selected using the maximum R^2, minimum Bayesian Information (BIC) criterion and Maximum Absolute Percentage Error (MAPE). Tahir (2014) examined some selected cereal crops (maize and sorghum) using trend analysis approach. The trends of crops' productivity were analyzed through graphical methods. Ratios and percentages were also used to measure productivity (yield) growth rates of the selected crops. The data was also subjected to different functional forms on line graphs and it was found that polynomial function gave the best fit due to its large coefficient of determination (R^2). It was also found that R^2 (=0.678) was strong for maize and R^2 (=0.292) was weak for sorghum. (Badmus and Ariyo, 2011) analyzed and forecasted time series variables cultivated area and production of maize (a component of cereal) using the ARIMA modeling technique. The best models for forecasting the areas and production of maize were found to be ARIMA (1, 1, 1) and ARIMA (2, 1, 2) models, respectively. The study therefore concluded that total cropped area can be increased in future, if land reclamation and conservation measures are adopted. Alabi (2008) applied comparative analysis approach to study the demand and supply for Maize and Sorghum in Kaduna and Kano State in Nigeria. Nerlove adaptation hypothesis and grafted polynomial models were used for demand function analysis. Export forecast for maize and sorghum show that there is a surplus of maize and sorghum in tonnes for a forecast period of 2006 to 2015. The conclusion was that supply has been identified as a limiting factor to agro-industrial development in Nigeria.

Materials and Methods

Source of data

In carrying out this study, an annual time series data on cereals production (CP) of Nigeria covering 1966-2016 was collected from the website http://data.worldbank.org. The data is made up of two components namely; the dependent variable and independent variable. The dependent variable is the CP while the independent variable is the time and time component is in years.

In this study, cereals production (CP) time series was first subjected to unit root test to determine whether it is stationary at level or not. The unit root test was conducted using the Augmented Dickey-Fuller (ADF) approach. Procedures of ADF are given below:

Unit root analysis

Augmented-Dickey Fuller (ADF) with constant and trend is adopted for the unit root analysis. The equation is specified as follows:

$$\Delta CP_t = \beta_1 + \beta_2 t + \delta CP_{t-1} + u_t \qquad (1)$$

Where: CP= random walk, β_1= constant, β_2=trend or time, δ= ρ-1, u_t= white noise error term and $CP_{t-1}$is the lagged one period of the CP variable.

The following hypothesis have been formulated with respect to equation (1)

H_0: δ=0 (CP has a unit root) versus H_1: Not H_0 (CP does not have a unit root)

Test statistic

The test statistic is given by: $t_\delta = \frac{\hat{\delta}}{Se(\hat{\delta})}$

Decision rule

Reject the null hypothesis if the p-value of the t-Statistic is greater than the level of significance $(\alpha = 0.05)$. Otherwise, we do not reject the null hypothesis.

Modeling approach

This study makes use of the ARIMA models developed by [9] to forecast the cereals production (CP) series from 2017 through 2026. The AR stands for the autoregressive i.e. regressing the dependent variables with linear combination of its lagged values, MA denotes moving average i.e. regressing the dependent error with linear combination of its past error or innovation and "I" denotes differencing order (i.e. number of differencing applied on the stochastic process to attain stationarity).

The model is given by:

$$CP_t = \mu + \emptyset_1 CP_{t-1} + \cdots + \emptyset_p CP_{t-p} + \theta_1 e_{t-1} + \cdots + \theta_q e_{t-q} + \varepsilon_t \qquad (2)$$

Where: CP_t= Cereals production (in metric tons) at period t; CP_{t-1}= Cereals production (in metric tons) at period t-1; CP_{t-p}= Cereals production (in metric tons) at period t-p; ε_t= Random shock at period t; ε_{t-1}= Random shock at period t-1; ε_{t-q}=Random shock at period t-q; μ, $\emptyset_p$ and $\theta_q$are parameters to be estimated

The following hypotheses have been formulated with respect to equation (2):

H_{01}: CP in (t-p) would have an impact on CP in current period t. Mathematically, the hypothesis is stated as follows:

H_0: $\emptyset_p$=0 against H_a: $\emptyset_p \neq 0$

H_{02}: Random shock in (t-q) period would have an effect on CP in period t. Mathematically, the hypothesis is stated as follows:

H_0: θ_q=0 against H_a: $\theta_q \neq 0$

ARMA modeling proceeds by a series of well-defined steps. These include:

Step 1: Model identification

Here, identification consists of specifying the appropriate structure (AR, MA or ARMA) and order of model. Identification is sometimes done by looking at plots of the autocorrelation function (ACF) and partial autocorrelation function (PACF). Sometimes identification is done by an automated iterative procedure – fitting many different possible model structures and orders and using a goodness-of-fit statistic to select the best model.

Step 2: Model estimation

Here, we estimate the coefficients of the model. Coefficients of AR models can be estimated by least-squares regression. Estimation of parameters of MA and ARMA models usually requires a more complicated iteration procedure. In practice, estimation is fairly transparent to the user, as it accomplished automatically by a computer program with little or no user interaction.

Step 3: Diagnostic checking

The third step is to check the model. This step is also called *verification*. Two important elements of checking are to ensure that the residuals of the model are random, and to ensure that the estimated parameters are statistically significant. Usually the fitting process is guided by the principle of *parsimony*, by which the best model is the simplest possible model – the model with the fewest parameters – that adequately describes the data.

Step 4: Forecasting

Once steps 1-3 are satisfied, then in-sample or out sample forecast can then be made.

Results and Discussion

The time plot in Fig. 1 indicates that the Cereals Production (CP) series is trending upward albeit with fluctuations. This means that the series is not stationary at level and need to be differenced once or twice in order to attain stationarity. The series is further subjected to unit root test to confirm the results reported by the Time plot. The results of the unit root tests are thus presented in Table 1.

Table 1 above reveals that the Cereal Production (CP) variable is stationary at its first difference since the p-value (= 0.0054) of the test statistic is less than the level of significance (α=0.05). Hence, it is an integrated series of order one denoted by I (1).

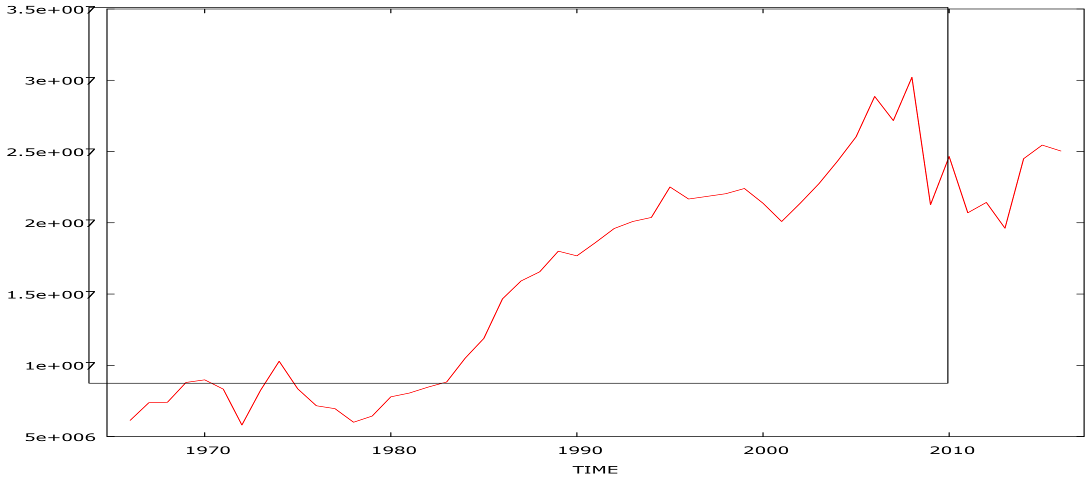

Fig 1: Time plot for the cereal production over a period 1966–2016

Table 1: Results of ADF test conducted on cereal production (CP) series

Variable	1st order autocorrelation for e	estimated value of (a - 1)	test statistic: tau_ct(1)	p-value
Cereal Production (CP)	0.0340	-0.9878	-4.1418	0.0054

Note: The p-value of the test statistic is significant

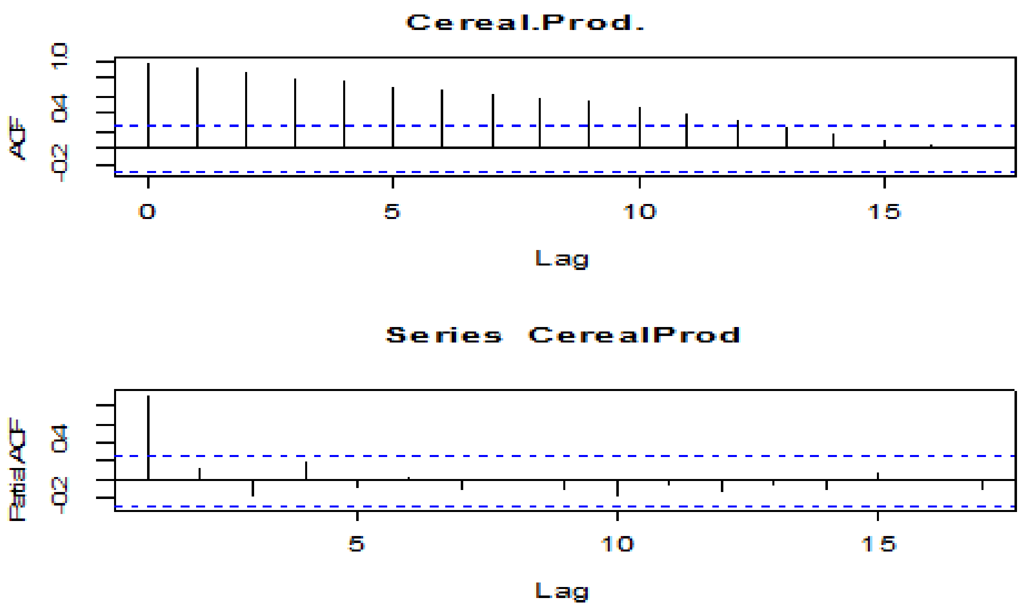

Fig 2: Autocorrelation and partial autocorrelation functions for cereal production (CP) series at level form

Fig. 2 shows that the spikes of the ACF are decaying geometrically while one spike is significant at one lag for the PACF. This means that ARIMA (1, 1, 0) model is suggested to fit the model. Further examinations of different possible fitted ARIMA (p, d, q) models are examined using selection criteria known as Akaike Information Criteria (AIC) and Bayesian Information Criteria (BIC). The results are presented in Table 3.

Table 3: Possible fitted ARIMA (p,d,q) models for the Cereal Production (CP) series; the best results as reported by the selection criteria are asterisked (*)

S/N	(p,d,q)	AIC	BIC	HQC
1	(1.1.0)	1595.702	1601.438	1597.887
2	(2,1,0)	1594.137	1601.785	1597.050
4	(0,1,2)	1595.946	1603.594	1598.858
5	(1,1,1)	**1593.580***	**1601.228***	**1596.493 ***
6	(1,1,2)	1595.179	1604.739	1598.820
7	(2,1,1)	1595.219	1604.779	1598.860
8	(2,1,2)	1595.791	1607.263	1600.160
9	(3,1,1)	1597.186	1608.658	1601.554
10	(1,1,3)	1597.078	1608.550	1601.447
11	(0,1,3)	1597.446	1607.006	1601.086
12	(3,1,0)	1595.312	1604.872	1598.953
13	(0,1,4)	1599.352	1610.824	1603.721
14	(4,1,0)	1597.307	1608.779	1601.675
15	(4,1,1)	1599.185	1612.570	1604.282

AIC= Akaike Information Criteria, BIC= Bayesian Information Criteria and HQC =*Hannan-Quinn Criteria*

Table 3 reveals that the least values of the selection criteria occur at ARIMA (1, 1, 1) model contrary to the ARIMA (1, 1, 0) model earlier suggested by the ACF and PACF in Fig. 2. Hence, the best model has been confirmed to be ARIMA (1, 1, 1) model. The estimates of the AR and MA terms of the model are presented in Table 4.

Table 4: Estimates of AR and MA terms in ARIMA (1, 1, 1) model

Variables	Coefficient	Std. Error	Z	p-value
Constant	369232	226799	1.6280	0.10352
AR1	-0.838637	0.132049	-6.3510	<0.00001***
MA1	0.585551	0.191034	3.0652	0.00218***
Mean dependent var	377911.6	S.D. dependent var		2086871
Mean of innovations	6167.576	S.D. of innovations		1856167
Log-likelihood	-792.7902	Akaike criterion		1593.580
Schwarz criterion	1601.228	Hannan-Quinn		1596.493

From Table 4, the estimated ARIMA (1, 1, 1) model is given by:

CP_t=369232−0.838637CP_{t-1}+0.585551ε_{t-1}+ε_t

Interpretation of the AR and MA terms in Table 4

For the AR term, the results showed that CP in (t-1) period is related to CP in current period because the p-value of the t-statistic (= 0.00001) is less than the level of significance (= 0.05)· We therefore conclude that the CP in immediate past period has a significant effect on present CP.

For the MA term, the results revealed the random shock in (t-1) periods is related to CP in present period since the p-value of the t-statistic (= 0.00218) is less than the level of significance (=0.05)· Hence, to forecast CP random shock of only one period lag should be taken into consideration in the case of CP of Nigeria. Further accuracy of the model was examined by the correlogram of its residual presented in Fig. 3.

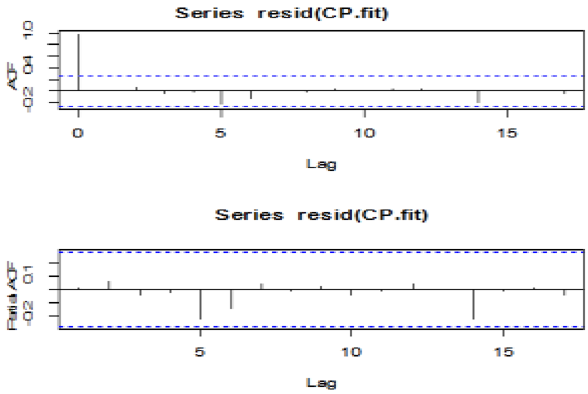

Fig 3: Correlogram of the residuals obtained from ARIMA (1, 1, 1) model

Table 5: Ten years forecast of the cereal production (CP) series

Year	Prediction	Std. error	95% Interval
2017	25000068.29	1856166.785	21362048.24 - 28638088.34
2018	25708731.72	2316775.136	21167935.89 - 30249527.55
2019	25793303.66	2921838.534	20066605.37 - 31520001.96
2020	26401262.12	3261831.478	20008189.90 - 32794334.34
2021	26570289.03	3690832.592	19336390.07 - 33804187.98
2022	27107420.38	3981997.830	19302848.05 - 34911992.71
2023	27335845.55	4325609.549	18857806.62 - 35813884.48
2024	27823163.30	4586932.585	18832940.63 - 36813385.96
2025	28093364.02	4879152.089	18530401.66 - 37656326.39
2026	28545647.22	5118903.271	18512781.17 - 38578513.27

Figure 3 showed that the spikes of the ACF and PACF of the residuals of the fitted ARIMA (1, 1, 1) model are not statistically significant. Hence, the model is a reasonable fit to the Cereals Production (CP) series. Having confirmed this, the next thing to do is forecast the CP series for the next ten years. The results of the forecast are thus presented in Table 5.

The goal of this study is twofold. Firstly, to uncover the pattern of cereals production (CP) series in Nigeria through the use of Time Plot and determination of the best possible model that fits the data. The best model for this study was found to be ARIMA (1, 1, 1) model. The model reveals that CP of present is related one period lag of its own value and one period lag of error term. To fulfill the second goal, forecasted CP of 10 years has been made by this model. The results obtained in the ten years forecast are presented in Table 5.

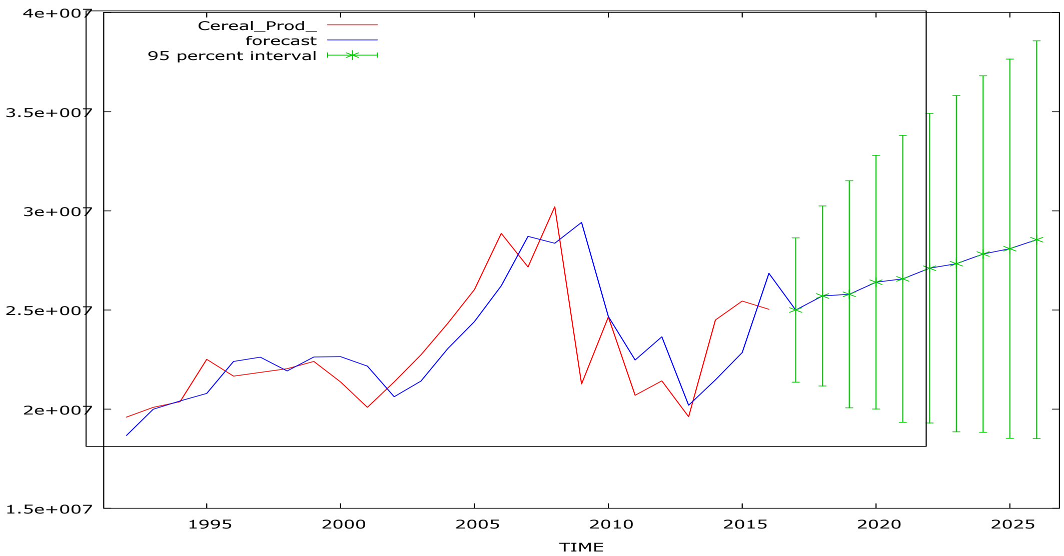

Fig. 4: Forecast plot of cereal production (CP) series from 2017-2026

From Table 5, the forecasted series are seen to be within the 95% confidence bounds. This is an indication that our forecasted values are good. Also the forecasted series will continue to increase for these forecasted time period.

According to Fig. 4, the Cereal Production has been shown to increase for the forecasted time period.

Conclusion

The aim of this study is to model and forecast the Cereals Production (CP) of Nigeria for the period of 2017 to 2026 using the ARIMA modeling techniques also known as Box-Jenkins (BJ) methodology. The modeling procedures are basically four steps. The first step is model identification; where the series was not stationary at level based on the results provided by both the time plot and ADF test. It was found stationary at its first difference. Based on the selection criteria AIC and BIC, reports showed that the ARIMA (1, 1, 1) model was confirmed to reasonably fit the data. The second step was the model estimation; where the CP of present was shown to be related to one period lag of its own value and one period lag of error term. Thirdly, the model was diagnosed and the results reported by the correlogram of the residuals showed that error derived from ARIMA (1, 1, 1) model is white noise. That is, the error was normally distributed, random and no presence of serial correlation. Finally, an out sample forecast for period of 10 years term was made; which shows that the CP will continue to increase for these forecasted time period.

The findings of this study have some important implications for Government at all levels to formulate better policies that will further harness the Nigerian cereals potentials as tools for boosting the Nigerian economy and an avenue for job creation.

However it would be interesting to expand this research work in the future by investigating the Cereal Productions (CP) variable along some other variables such as Cereal Yield (CY) etc. using multivariate time series approach.

Conflict of Interest

Authors have declared that there is no conflict of interest reported in this work.

References

Alabi OO 2008. Comparative Analysis of Industrial Demand and Supply for Maize and Sorghum in Kaduna and Kano States of Nigeria. In http://www.patnsukjournal.com/currentissue PAT, 4(2): 14-21.

Akande SO 1994. Comparative Cost and Return in Maize Production in Nigeria. Nigeria Institute for Social and Economic Research (NISER) Individual Research Project Report, Ibadan. NISER.

Awika JM 2011. Major Cereal Grains Production and Use around the World. Soil & Crop Science Dept./Nutrition and Food Science Dept., Texas A&M University, 2474 TAMU, College Station, TX 77843-2474. *An Unpublished Manuscript.*

Badmus MA & Ariyo OS 2011. Forecasting cultivated areas and production of maize in Nigeria using ARIMA Model. *Asian J. Agric. Sci*., 3(3): 171-176.

Box GE & Jenkins GM 1976. Time Series Analysis, Forecasting and Control. San Francisco, Holden-Day Inc., USA.

Dogget H 1988. Sorghum, Tropical Agricultural Series, Essex 2nd edition, England Longman Scientific and Technical.

FAO 2007. In http://www.fao.org/docrep/009/a0773e/a0773e00.htm

Idem NUA & Showemimo FS 2004. Cereal Crop of Nigeria.

Ismaila U, Gana AS, Tswanya NM & Dogara D 2010. Cereals production in Nigeria: Problems, constraints and opportunities for betterment. *Am. J. Agric. Res.,* 5(12): 1341-1350.

Kotra SW & Sheik NU 2016. Forecasting of Rabi Cereals Production in Andhra Pradesh Using ARIMA Models, 6(7): 8275-8277.

NEARLS 1996. Prospects and problems of the 1996 cropping season. A report of a study conducted by the National Agricultural Extension Research and Liaison Services (NEARLS) and Agricultural Planning Monitoring and Evaluation Unit (APMEU), 2-3 Oct., 1996. (NEARLS), Ahmadu Bello University, Zaria.

Reichert RD 1982. Sorghum Dry Milling pg 547-56 in: Sorghum in the Eighties Proceedings of the International Symposium Patancheru, AP, 502324 India.

Tahir HM 2014. Trend analysis of productivity of some selected cereal crops in Nigeria: 1983-2008. *Res. on Humanities and Soc. Sci*., 4(8): 110-116.