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Full Length Research Paper

Intervention analysis of fertilizer input subsidy on maize production in Ghana

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In a response to global oil and food crisis in 2007/2008, the Ghana government introduced a fertilizer subsidy program as a measure to ease the effects of the food crisis by increasing food production through fertilizer use. Interrupted Time Series Analysis (Intervention Analysis) was used to investigate the effect of the fertilizer subsidy program on Ghana's maize production in this work. Secondary data representing Ghana's annual maize production from 1960 to 2015 were used for the analysis in this study. An ARIMAX model with a set of pulse functions was then developed to examine to the effect the fertilizer subsidy program. Estimation results of the ARIMAX model revealed that the fertilizer subsidy program contributed to significant improvements in maize production for 2008, 2009, 2010 and 2012. For 2011, 2013 and 2015 however, the estimation results of the ARIMAX model revealed that the fertilizer subsidy program did not contribute to significant improvements in maize production in Ghana. On the basis of the research findings, the study was concluded by indicating the need for a proper reexamination and evaluation of the implementation process of the subsidy program in order to realize significant improvements in maize production in Ghana.

Keywords: Interrupted Time Series, ARIMAX, pulse functions, fertilizer subsidy.

INTRODUCTION

Maize is a cereal crop that is grown widely throughout the world in a range of agro-ecological environments (Biwott and Ngeywo, 2015). Maize is the most important cereal crop in sub-Saharan Africa (SSA) and serves as an important staple food for more than 1.2 billion people in SSA and Latin America. It is indicated that more than 116 million tons of maize are consumed worldwide with Africa and SSA consuming 30% and 21% respectively. And the worldwide production of maize is 785 million tons with Africa producing 6.5% (IITA, 2016).

Maize is Ghana's number one staple food crop, accounting for more than 50 percent of the country's total cereal production. However, the average maize yield in Ghana remains one of the lowest in the world, much lower than the average for Africa south of the Sahara whilst its domestic demand is growing (Ragasa et al., 2014). Ghana has experienced average shortfalls in domestic maize supplies of 12 percent in recent years (Millennium Challenge Account, 2009). Therefore, the Government of Ghana with the aim of increasing crop production and in a response to global oil and food crisis, introduced an intervention program, the national fertilizer subsidy program in the country. The implementation of the program was significantly important in helping to make fertilizer more affordable and to enable many farmers use fertilizer in farming so as to help increase crop production in the country (Wanzala-Mlobela et al., 2013).

As the aim of the program was to help increase crop production, investigation regarding the extent of the effectiveness of the program on maize production is needed to reveal its full benefit and this was the main focus of this work. To achieve this, the study sought to develop an ARIMAX model to address the following research questions: that is, given the implementation of the fertilizer subsidy program in the country,

1. Has there been any evidence of a change in maize production (such as an increase in the mean levels)? And
2. If so, by how much?

The Intervention

Since 2008, one key agricultural policy intervention program that the Ghana government introduced through its sector ministry, the Ministry of Food and Agriculture was the national fertilizer subsidy program. The program was aimed at enhancing food production and security in the country. Apart from the year 2014, the program has been progressively pursued on a yearly basis from 2008 through to 2015 and it involved the government absorbing part of the cost of fertilizer and thereby reducing the price of fertilizer to farmers. The subsidy program was intended to make fertilizer affordable for many farmers and increase its application rate in the country so as to increase crop production (Akatey, 2015).

REVIEW OF LITERATURE

Fertilizers provide plants with the nutrients they need for growth and development. To maintain soil fertility and productivity and prevent land degradation, nutrients taken up by crops are required to be replenished through the application of fertilizers. The use of fertilizer results in many benefits such as increased agricultural outputs, mainly food and fiber (Lal and Stewart, 2010).

Before the inception of the national fertilizer subsidy program in 2008, it is estimated that the fertilizer application rate was 8kg per hectare in Ghana, one of the lowest in the world in comparison to the application rate of 20kg/ha in sub-Saharan Africa, 99kg/ha in Latin America, 109 kg/ha in South Asia and 149 kg/ha in east and southeast Asia. The low application rate was mainly attributed to the high cost of fertilizers. Invariably, the end result was the inability of many farmers to afford the product, thereby giving rise to low crop production in Ghana. The introduction of the national fertilizer subsidy program was therefore aimed at making fertilizer affordable to many farmers so as to help increase the fertilizer application rate in the country with the ultimate goal of improving production levels of crops (Akatey, 2015).

By the introduction of the national fertilizer subsidy program, six fertilizer companies which were contracted for the program included the following: Yara Ghana Ltd, Chemico Gh. Ltd, Afcott Ghana Ltd, AMG West Africa Ltd, Louis Dreyfus Commodities Ltd and ETC Ghana Ltd. These companies have since been used as the marketing and sales companies through their accredited sales agents for the products in the country. One issue of major concern has been the unavailability of subsidized fertilizer when it is needed most (Ragasa et al., 2014). Consequently, farmers are compelled to go in for the readily available unsubsidized fertilizer at high cost. Notwithstanding the problems, the fertilizer application rate has increased to12kg per hectare in Ghana presently (Akatey, 2015).

To evaluate the effect of the fertilizer subsidy program on maize production, nationwide annual maize production (measured in units of 1000 metric tons) from 1960 to 2015 forming a time series was examined.

Time Series is a sequence of observations ordered in time, which are mostly collected at equally spaced, discrete time intervals (Agrawal et al., 2012). Time series are frequently affected by certain external events such as holidays, strikes, sales promotions and other policy changes. These external events are referred to as interventions. The fertilizer subsidy program was expected to influence crop production levels and was hence considered an intervention in this study. Intervention Analysis is described as a technique used to evaluate the effect of these external events (Wei, 2006). Intervention analysis developed by Box and Tiao (1975) has been successfully applied in various fields. Ledolter and Chan (1994) for example, examined whether a significant change in fatal and major-injury accident rate can be detected following the implementation of a higher speed limit in the state of Iowa using intervention analysis. The findings from their study revealed that the increase in speed limit on Iowa's rural interstate highways in 1987 contributed to a rise in fatal accidents.

Noland et al. (2008) also investigated the effect of a congestion charge on traffic casualties for motorists, pedestrians, cyclists and motorcyclists, both within the charging zone and in areas of London outside the zone using intervention analysis. They adopted the Box-Tiao intervention analysis in the study. The result showed that there was no significant effect for the total causalities, but within the charging zones, there were significant effects of casualties for motorists and cyclists.

Yaacob et al. (2011) evaluated the effects of OPS Sikap on road accidents in Malaysia using intervention analysis by assessing the intervention effect in comparison with the standard ARIMA model, and hence to obtain the best model for forecasting purposes. The findings revealed that there was a drop in the number of road accidents during OPS Sikap II, VI, VIII, XII, and XIV, but the significant reduction could only be seen after the implementation of OPS Sikap VII and XIV interventions. In modeling the noise series, traditional Box-Jenkins approach involving the use of autocorrelation function (ACF) and partial autocorrelation function (PACF) was adopted in determining the model orders.

In this study, Order Identification Diagnostic Technique involving the use of extended sample autocorrelation function (ESACF) and smallest canonical (SCAN) correlation method was used as an additional procedure to help in properly identifying the noise model.

MATERIALS AND METHODS

The concept of Interrupted Time Series Analysis was employed in this work to evaluate the impact of the national fertilizer subsidy program on maize production in Ghana. The data representing nationwide annual maize production (measured in units of 1000 metric tons - 1000 MT) spanning from a period of 1960 to 2015 forming a time series were used for the analysis in this study. The data were obtained from a secondary source (Index Mundi, 2016) and were analyzed using SAS as the statistical software.

Intervention Time Series Analysis

Intervention time series analysis is a method used in evaluating the effect of external events on a time series (Wei, 2006). The effects of external events are determined using ARIMAX models. An ARIMAX model is an Autoregressive Integrated Moving Average (ARIMA) model with an input series according to Pankratz (1991) as cited by Yogarajah et al. (2013). An ARIMA model is a combination of Autoregressive (AR) and Moving Average (MA) models with a differencing factor. The autoregressive model shows the relationship between the present value and past values of a series, plus a random value while the moving average model describes the relationship between the present value of the series and past residuals. An ARIMA model of order (*p*, *d*, *q*) denoted by ARIMA(*p*, *d*, *q*) is defined according to Wei (2006) as follows;

$$\emptyset_p(\boldsymbol{B})(1-\boldsymbol{B})^d \mathrm{Y}_t = \theta_0 + \theta_q(\boldsymbol{B})\mathrm{a}_t \; \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; (1)$$

Where
$\mathrm{Y}_t =$ the observed series (annual maize production records)
$\theta_0 = Mean\ of\ \mathrm{Y}_t$,
$\emptyset_p(B) = 1 - \varphi_1\boldsymbol{B} - \ldots - \varphi_p \mathrm{B}^{\mathrm{p}}$,
$\theta_q\ (\boldsymbol{B}) = 1 - \theta_1\boldsymbol{B} - \ldots - \theta_q \mathrm{B}^{\mathrm{q}})$,
φ_i = The i^{th} Autoregressive parameter,
θ_i = The i^{th} Moving Average parameter,
p, q and d denote the autoregressive, moving average and differenced orders respectively,
B is the backward shift operator and
$\{\mathrm{a}_t\}$ is a zero mean white noise process with constant variance σ_a^2.

Analyzing the Intervention Effect

To examine the effect of the fertilizer subsidy program, the modeling process was divided into two phases. The first phase of the modeling process was the pre-intervention analysis, which involved: model identification and diagnostic checking for the period before the intervention was introduced. This period is referred to as the noise season with the series called noise series (Wei, 2006).

Identification

The model identification involved determining a tentative ARIMA model referred to as a noise model denoted by N_t. This was achieved by identifying the proper values for the orders of the AR and MA components. The respective orders of the MA and AR components p and q can be determined by using the sample Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) respectively (Wei, 2006). Before the model orders are determined, the time series is required to be stationary.

Order Identification Diagnostic Technique was an additional procedure used to identify the model orders in this work. The Order Identification Diagnostic Technique involved the use of extended sample autocorrelation function (ESACF) and smallest canonical (SCAN) correlation method where final tentative model orders were determined at 5% significance level.

The SCAN method uses a SCAN table from which tentative model orders are identified by finding a (maximal) rectangular pattern in which the smallest canonical correlations are insignificant for all test orders $m \geq p + d$ and $j \geq q$ where m is Autoregressive test order, j is moving-average test order, $p + d$ is a true autoregressive order with a true Moving-Average order of q (Tsay and Tiao, 1985).

In the ESACF method, an ESACF table is used from which tentative model orders are identified by finding a right (maximal) triangular pattern with vertices located at $(p + d, q)$ and $(p + d, q_{max})$ and in which all elements (extended sample autocorrelations) are insignificant (based on asymptotic normality of the autocorrelation function) where q_{max} represents maximum Moving Average test order (Tsay and Tiao, 1984).

Stationarity

A time series is stationary if it has a constant mean and constant variance with the autocorrelation function dependent only on the time lag. A non stationary series can be made stationary by differencing the data. The number of times the series is differenced gives the value of d. For a stationary series, $d = 0$ and ARIMA (p, d, q) can be written as ARMA (p, q). To test for stationarity, Augmented Dickey Fuller (ADF) test was used in this work. The ADF test examines the null hypothesis that the series is nonstationary (Wei, 2006).

Autocorrelation and Partial Autocorrelation Functions

Autocorrelation describes the way observations in a time series are related to each other and is measured by the correlation between current observation (Y_t) and the observation from p periods before the current one (Y_{t-p}). Partial autocorrelation describes the degree of association between Y_t and Y_{t-p} when the Y- effects on other time lags 1, 2, 3, …, $p-1$ are removed (Ramasubramanian, 2007). A plot of autocorrelation coefficients at various lags called autocorrelation function (ACF) is useful in identifying the order of MA component, whereas partial autocorrelation function (PACF) is useful in identifying the order of AR component in an ARIMA model (Wei, 2006)

Diagnostic checking

After identifying the model, the parameters are estimated and the model checked for adequacy through residual analysis. That is, the residuals are checked to see if the model assumptions are satisfied. The basic assumption is that the residuals are white noise. This assumption was tested by using the modified Box-Pierce Q statistic $\left(\tilde{Q}(\hat{r})\right)$, which is defined below according to Ljung and Box (1978).

$$\tilde{Q}(\hat{r}) = n(n+2)\sum_{k=1}^{h}(n-k)^{-1}\hat{r}_k^2 \quad \ldots\ldots\ldots\ldots(2)$$

where

$\hat{r}_k$ = The residuals autocorrelation at lag k

n = The number of residuals

h = The number of time lags included in the test

When the p-values are large(>0.05) for the chi-square statistic at various lags, the residuals are said to be uncorrelated and the model is considered adequate, otherwise a new model is used and the process repeated (Wei, 2006). In this study, all tests were performed at a significance level of 5%.

In the second phase of the modeling process, the noise model identified in the first phase was used to hypothesize the effect of the intervention by using a set of pulse functions for the intervention variable. A pulse function represents an intervention that occurs at only one time period, T. It is defined according to Wei (2006) as,

$$P_t^{(T)} = \begin{cases} 1, & t = T, \\ 0, & t \neq \mathrm{T}. \end{cases} \quad \ldots\ldots\ldots\ldots\ldots (3)$$

The general response function for the intervention variable used is given according to Wei (2006) as

$$\frac{\omega(B)B^b}{\delta(B)} \quad \ldots\ldots\ldots \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

where $\omega(B) = \omega_0 - \omega_1 B - \ldots - \omega_s B^s$,

$\delta(B) = 1 - \delta_1 B - \ldots - \delta_r B^r$, b is the time delay for the intervention effect and ω_j represents the expected initial effect of the j^{th} intervention and $\delta(B)$ measures the behavior of the permanent effect of the intervention wi th s and r being non negative integers.

Thus, the general form of the ARIMAX model using the response function is given as,

$$Z_t = \theta_0 + \sum_{j=1}^{k}\frac{\omega_j(B)B^{bj}}{\delta_j(B)} I_{jt} + \frac{\theta(B)}{\psi(B)} a_t \ \ldots\ldots\ldots\ldots (5)$$

Where I_{jt}, j= $1, 2, \ldots, k$ are intervention variables, $\omega_j(B)B^{bj}/\delta_j(B)$ represents the jth intervention response form and $[\theta(B)/\psi(B)]\, a_t$ is the noise model (Wei, 2006).

The fertilizer subsidy program was implemented on a yearly basis from 2008 to 2013 and then again in 2015. Apart from 2014, each of the years from 2008 to 2015 represented the intervention periods. Each of the intervention periods was expected to positively influence to production level of maize in Ghana. The yearly interventions from 2008 to 2015 were then defined in the forms of pulse functions so as to capture the intended effect of the yearly subsidy programs. Thus, the variables: $I_{1t},\ I_{2t},\ I_{3t},\ I_{4t},\ I_{5t},\ I_{6t}\ and\ I_{7t}$ were used to denote the pulse functions for the yearly intervention periods of 2008, 2009, 2010, 2011, 2012, 2013 and 2015 respectively. The pulse functions were then incorporated in the noise model, which then resulted in the proposed ARIMAX model for the study as follows.

$$Z_t = \omega_1 I_{1t} + \omega_2 I_{2t} + \omega_3 I_{3t} + \omega_4 I_{4t} + \omega_5 I_{5t} + \omega_6 I_{6t} + \omega_7 I_{7t} + \frac{\theta(B)}{\psi(B)} a_t \ \ldots\ldots\ldots\ldots\ldots(6)$$

where

$$I_{1t} = \begin{cases} 1 & t = 2008 \\ 0, & t \neq 2008 \end{cases}$$

$$I_{2t} = \begin{cases} 1 & t = 2009 \\ 0, & t \neq 2009 \end{cases}$$

$$I_{3t} = \begin{cases} 1 & t = 2010 \\ 0, & t \neq 2010 \end{cases}$$

$$I_{4t} = \begin{cases} 1 & t = 2011 \\ 0, & t \neq 2011 \end{cases}$$

$$I_{5t} = \begin{cases} 1 & t = 2012 \\ 0, & t \neq 2012 \end{cases}$$

$$I_{6t} = \begin{cases} 1 & t = 2013 \\ 0, & t \neq 2013 \end{cases}$$

$$I_{7t} = \begin{cases} 1 & t = 2015 \\ 0, & t \neq 2015 \end{cases}$$

and ω_1, ω_2, ω_3, ω_4, ω_5, ω_6, ω_7 represent the coefficients of the pulse functions for 2008, 2009, 2010, 2011, 2012, 2013 and 2015 respectively. The method of maximum likelihood was used in the estimation of model parameters in this study.

RESULTS AND DISCUSSION

In Figure1 below, a plot of the original series (annual maize production levels) did not seem to indicate stationarity. The ACF plot showed a very slow decay, which suggested nonstationarity in the series. The Augmented Dickey Fuller (ADF) test also produced large p-values (>0.05) shown in Table1 below that suggested that the series was not stationary. The original series was then differenced in order to achieve stationarity.

In Figure 2 below, a plot of the series in first difference depicted a pattern of fluctuations around a constant mean thereby suggesting stationarity. The ACF of the first difference cut off after lag 1 which equally suggested stationarity. The ADF test shown in Table 2 provided small p-values (<0.05) also confirming stationarity and hence no need for higher differencing or transformation.

Results from the SCAN and ESACF methods shown in Table 3 below provided tentative model orders at 5% significance level. The orders indicated the following as tentative models: ARIMA(1 1 0), ARIMA(0, 1, 1), ARIMA(1, 1, 1), ARIMA(2, 1, 1), ARIMA(3, 1, 1), ARIMA(4, 1, 1) and ARIMA(5, 1, 1). The models were evaluated and ARIMA(1, 1, 1), ARIMA(4, 1, 1) and ARIMA(5, 1, 1) produced large p-values of the Ljung-Box statistic at all lags as shown in Table 4 below. Thus, ARIMA(1, 1, 1), ARIMA(4, 1, 1) and ARIMA(5, 1, 1) were considered adequate noise models since the residuals showed no form of serial correlation.

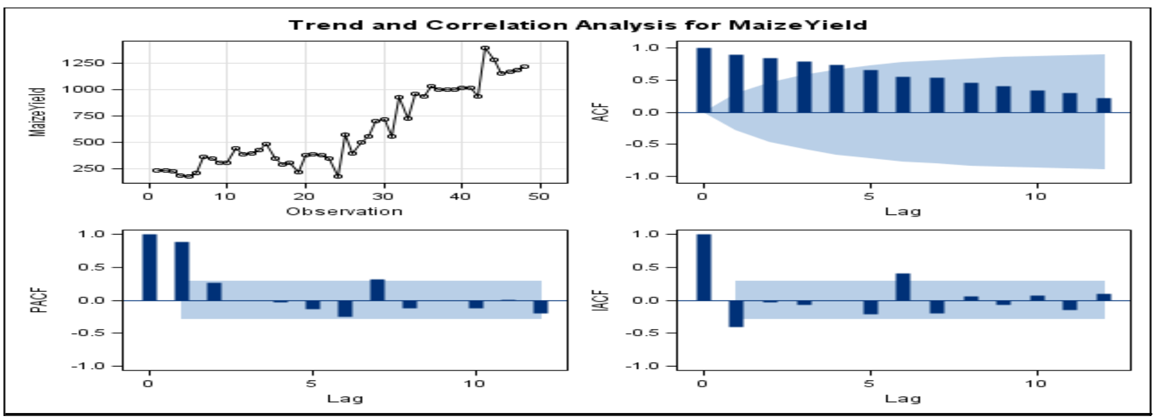

Figure 1. Trend and Correlation Analysis for the maize production.

Table 1. ADF test results.

Augmented Dickey-Fuller Unit Root Test							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	1.1396	0.9263	1.42	0.9594		
	2	1.2141	0.9355	1.77	0.9799		
	3	1.2489	0.9393	2.00	0.9879		
Single Mean	1	-0.3201	0.9355	-0.20	0.9313	1.57	0.6785
	2	0.0103	0.9543	0.01	0.9542	2.12	0.5442
	3	0.1153	0.9593	0.10	0.9619	2.67	0.4109
Trend	1	-9.916	0.3969	-2.25	0.4502	2.79	0.6328
	2	-7.667	0.5767	-1.91	0.6335	2.13	0.7575
	3	-5.9129	0.7304	-1.61	0.7722	1.58	0.8607

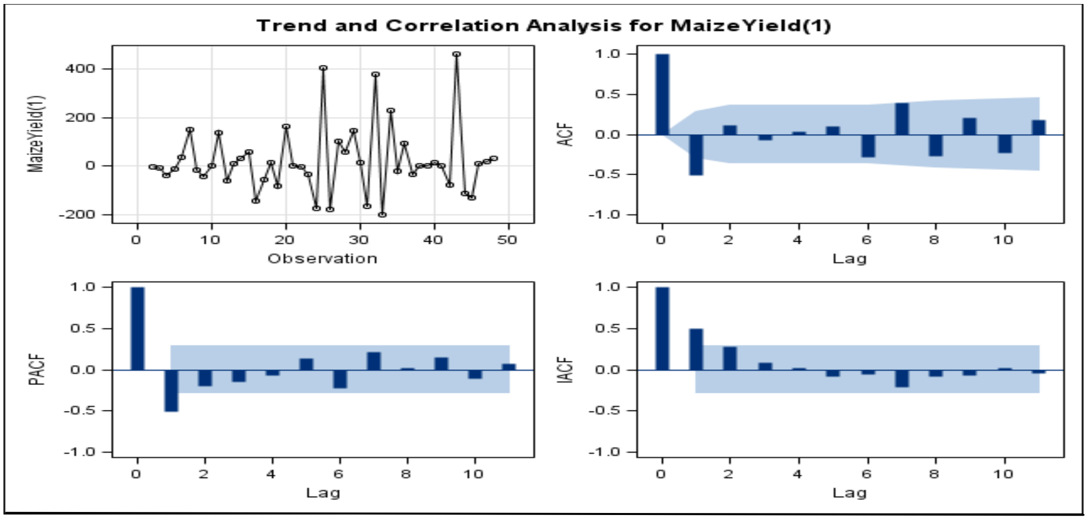

Figure 2. Trend and Correlation Analysis for the Differenced Series.

Table 2. ADF test results of differenced series.

Augmented Dickey-Fuller Unit Root Test							
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero Mean	1	-84.2382	<.0001	-6.34	<.0001		
	2	-97.1635	<.0001	-4.64	<.0001		
	3	-68.6490	<.0001	-3.47	0.0009		
Single Mean	1	101.608	0.0001	-6.90	0.0001	23.80	0.0010
	2	-224.197	0.0001	-5.41	0.0001	14.64	0.0010
	3	-11507.5	0.0001	-4.39	0.0010	9.65	0.0010
Trend	1	-104.576	0.0001	-6.90	<.0001	23.83	0.0010
	2	-263.330	0.0001	-5.42	0.0003	14.73	0.0010
	3	659.7469	0.9999	-4.40	0.0058	9.76	0.0010

Table 3. Results of SCAN and ESACF methods.

SCAN Chi-Square[1] Pobability Values

Lags	MA 0	MA 1	MA 2	MA 3	MA 4	MA 5
AR 0	0.0002	0.5407	0.7035	0.8422	0.5773	0.0744
AR 1	0.1724	0.7426	0.9495	0.7059	0.4520	0.2921
AR 2	0.1362	0.8879	0.7440	0.5750	0.8030	0.9759
AR 3	0.6080	0.3418	0.5350	0.7377	0.8908	0.7696
AR 4	0.4027	0.9994	0.8627	0.8502	0.6238	0.3240
AR 5	0.1030	0.7565	0.8704	0.8502	0.8139	0.4021

ESACF Probability Values

Lags	MA 0	MA 1	MA 2	MA 3	MA 4	MA 5
AR 0	0.0005	0.5373	0.6977	0.8390	0.5692	0.1155
AR 1	0.0170	0.0564	0.8972	0.9136	0.7868	0.5324
AR 2	0.0011	0.1720	0.9081	0.7157	0.8353	0.8954
AR 3	0.0050	0.6656	0.3913	0.5401	0.8098	0.9312
AR 4	0.0063	0.9690	0.4517	0.9201	0.8328	0.8291
AR 5	0.0200	0.9524	0.5152	0.7385	0.7810	0.8660

ARMA(p+d,q) Tentative Order Selection Tests

………….SCAN…………		…………..ESACF………………	
p+d	q	p+d	q
1	0	0	1
0	1	1	1
		2	1
		3	1
		4	1
		5	1

5% Signifcance Level

Table 4. **Ljung-Box Statistic**

Model	p-values			
	lag6	**lag 12**	**lag18**	**lag24**
ARIMA(1, 1, 0)	0.6731	0.3655	0.037	0.0505
ARIMA(0, 1, 1)	0.4702	0.0945	0.0301	0.0595
ARIMA(1, 1, 1)	**0.6287**	**0.2694**	**0.0537**	**0.079**
ARIMA(2, 1, 1)	0.3479	0.395	0.032	0.0467
ARIMA(3, 1, 1)	0.2813	0.1381	0.0308	0.053
ARIMA(4, 1, 1)	**0.3131**	**0.2089**	**0.1107**	**0.1363**
ARIMA(5, 1, 1)	**-**	**0.7388**	**0.4722**	**0.4447**

In the second phase of the modeling process, the noise models identified were used to hypothesize the effect of the intervention using a transfer function of the intervention variables. The resultant ARIMAX models were evaluated and the ARIMAX model developed from ARIMA(5, 1, 1) produced large p-values (>0.05) of the Ljung-Box statistic at all lags as shown in Table 5 below. The results for the ARIMAX model developed from ARIMA(5, 1, 1) indicated that, the residuals were uncorrelated and hence the model represented an adequate intervention model and given as follows.

$$Z_t = \omega_1 I_{1t} + \omega_2 I_{2t} + \omega_3 I_{3t} + \omega_4 I_{4t} + \omega_5 I_{5t} + \omega_6 I_{6t} + \omega_7 I_{7t} + \frac{(1-\theta_1 \boldsymbol{B})}{(1-B)(1-\varphi_1 \boldsymbol{B} - \varphi_2 \boldsymbol{B}^2 - \varphi_3 \boldsymbol{B}^3 - \varphi_4 \boldsymbol{B}^4 - \varphi_5 \boldsymbol{B}^5)} a_t \quad ...(7)$$

Results of further residual analysis shown in Figure 4 and Figure 5 below for the intervention model showed the residuals to be normally distributed and with no serial correlation respectively. Overall, the residuals did not show any form of departure from white noise, hence confirming that the model was adequate and satisfactory. The Maximum Likelihood estimates of the intervention variables in Table 6 below were all positive, which represented as an evidence of increments (improvements) in maize production during the years for the implementation of the intervention program except 2015. The results from Table 6 below indicated that for 2008, 2009, 2010 and 2012, there were significant improvements in maize production by 268241 MT, 256496 MT, 479121 MT and 401036 MT respectively. These were revealed by the small p-values (<0.05) corresponding to the respective years. For 2011 and 2013, the respective improvements in maize production of 181183 MT and 115623MT were not significant as revealed by the large p-values (>0.05) corresponding to the respective years. In 2015 however, there was a shortfall in maize production by 277,812 metric tons.

Table 5. Ljung-Box test for ARIMA models with intervention variables (ARIMAX models)

	p-values			
Model	**lag 6**	**lag 12**	**lag18**	**lag24**
ARIMA(1, 1, 1)	0.5904	0.1595	0.0123	0.0084
ARIMA(4, 1, 1)	0.4091	0.2142	0.0774	0.0489
ARIMA(5, 1, 1)	**.**	**0.7038**	**0.3444**	**0.2372**

Table 6. Estimation results of intervention model.

Parameter	Standard Estimate	Approx Error	t Value	Pr >$\lvert t \rvert$	Lag	Variable	Year
θ_1	-0.84361	0.15332	-5.50	<.0001	1	MaizeYield	
φ_1	-1.14799	0.19064	-6.02	<.0001	1	MaizeYield	
φ_2	-0.29993	0.24017	-1.25	0.2117	2	MaizeYield	
φ_3	0.13481	0.24859	0.54	0.5876	3	MaizeYield	
φ_4	0.32509	0.25217	1.29	0.1973	4	MaizeYield	
φ_5	0.34230	0.17448	1.96	0.0498	5	MaizeYield	
ω_1	268.24089	129.52053	2.07	0.0384	0	I_{1t}	2008
ω_2	256.49612	125.55766	2.04	0.0411	0	I_{2t}	2009
ω_3	479.12088	133.87295	3.58	0.0003	0	I_{3t}	2010
ω_4	181.1829	134.70108	1.35	0.1786	0	I_{4t}	2011
ω_5	401.03642	136.07747	2.95	0.0032	0	I_{5t}	2012
ω_6	115.62246	126.98316	0.91	0.3625	0	I_{6t}	2013
ω_7	-277.81205	143.66081	-1.93	0.0531	0	I_{7t}	2015

CONCLUSION

The study sought to evaluate the effect of the nationwide implementation of the fertilizer subsidy intervention program. Thus, an intervention model with a set of pulse functions was adopted to model the interrupted effect of the intervention on maize production in Ghana. The residuals of the intervention model were uncorrelated and hence did not show any form of departure from white noise thereby indicating that the model was appropriate and adequate. Except for 2015, the estimation results from Table 6 above provided evidence of improvement in maize production during the years of implementation of the intervention program. There were significant improvements (p-values <0.05) in maize production for 2008, 2009, 2010 and 2012. For 2011 and 2013, the improvements in maize production were not significant and for 2015, there was a shortfall in maize production in Ghana by 277,812 metric tons. On the basis of the research findings, there is the need for a proper reexamination and evaluation of the implementation process of the intervention program in order to realize significant improvements in maize production in Ghana. The findings of this paper are particularly important as they are consistent with that of Kwao (2014). Other challenges confronting production levels of the cereal, which are not considered in this paper should also be examined in an effort to improve maize production in Ghana.

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