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Long Run Co Integration Modeling for Rainfall, Yield and Prices of Cereals and Legume in Nigeria

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Authors' contributions

This work was carried out in collaboration between all the authors. Author GAA designed the study, wrote the protocol and reviewed all the draft. Author IET collected and analyzed the data and wrote the first draft of the manuscript. Author PIA managed the literature searches and conducted diagnostic test on the variables. All authors read and approved the final manuscript.

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ABSTRACT

This study established a long run relationship in rainfall, yield and prices of soya bean, rice and maize for (1975-2009) period in Nigeria. Annual secondary time series data on selected parameters were collected in thirty six states including Abuja in six agro ecological zones and analysed. The result revealed that mean yield of soya bean, rice and maize in Nigeria were 0.52 mt/ha, 1.76 mt/ha, 1.38 mt/ha respectively. The average price of soya bean, rice and maize were ₦80, 316.38, ₦95, 044.85 and ₦85, 140.00 per ton respectively. Average rainfall figure was 1953.51mm/annum with the range of 594 to 4,046. The Augmented Dickey Fuller (ADF) test of stationarity revealed that rainfall; yield and prices of soya bean, rice and maize were non stationary at level but stationary on first differencing. The Johansen Co integration analyses revealed a long run equilibrium relationship among rainfall, yield and prices of soya bean, rice and maize. Further analysis using Vector Error Correction Model (VECM) on these variables showed that soya bean price had a negative influence (-0.11) on soya bean yield, variation in rice prices had no significant causal influence on rice yield.

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Contrarily maize price variation had significant positive influence on maize yield (0.08) though with low magnitude. Regarding rainfall generally, the study showed that rainfall had a significant negative influence (-0.44,-1.01,-0.21) on yield of soya bean, rice and maize respectively. Short run analysis of Granger causality test showed no causal influence in the short run for all the variables. Also the result of impulse response showed that shocks to any of the variables had a persistent effect on the others for more than ten years. Based on the findings of this study, it is recommended that Co integration model should be adapted in using time series data to achieve more effective and efficient result in prediction and policy evaluation in long run situations. Above all, sustainable productivity, increased growth and economic development can be achieved if marketing can be more efficiently organized for more attractive producer prices for increased production of soya bean and cereals annually.

Keywords: Long run; co integration; modeling; rainfall; yield; prices.

1. INTRODUCTION

Agriculture plays a key role in poverty reduction, economic growth and development of a nation [1,2,3]. In many parts of developing economies including Nigeria, most farmers are dependent on rainfall and practice small scale agriculture, rather than a profit driven commercial agriculture. The magnitude of supply or production of agricultural commodities is usually a reflection of farmers' response to financial incentives such as prices. Farmers anticipate prices which they are likely to get from their produce. The wide and dramatic swing of prices is the key factor responsible for the fluctuation in the supply or production of agricultural commodities in developing countries like Nigeria. Thus, agricultural yield in tropical and developing countries to a large extent depends on these two interlocking factors of rainfall and prices prevalent in these areas. Maize is one of the major staples in Nigeria and therefore is of vital concern to agricultural policy decisions. Current maize production is about 8 million tonnes and average yield is 1.5 tonnes per hectare. The average yield is low when compared to world average of 4.3 tonnes/ha from other African countries like South Africa with 2.5 tonnes/ha, Cameroon, 1.9 tonnes/ha, Ethiopia, 1.8 tonnes/ha and Kenya, 1.7 tonnes/ha [4].Soya bean (*Glycine max (L) Meril*) a leguminous crop of great economic importance has been receiving attention by the Nigerian government for a long period of time. In the year 2007/2008 Nigeria produced 450,000 MT, this is still insufficient to satisfy domestic demand to attenuate soya bean importation [5]. Therefore it is both a national survival and economic imperative that strategies are designed to sustain soya bean production to meet present and future domestic needs as well as exports. According to [6] the marketing system for soya bean has been inefficient with poor marketing prices, as well as high marketing costs. While most farmers complained that they are ready to produce soya bean, whom to sell their soya bean to has been a major constraint as they need good pricing arrangements that do not work against them [7]. Average yield levels are approximately 1.2 MT/ha. Soya bean are produced on smallholder farms averaging not more than one hectare, as a result it is non-mechanized [8]. According to [9], rice production is predominantly rain fed in Nigeria as over 90% rice produced in the country is through this system. Yield per hectare is low due to production systems, aging farming population and low competitiveness with imported rice [10]. According to [10], the annual domestic output of rice still hovers around 3.0 million metric tons, leaving the huge gap of about 2 million metric tons annually, a situation, which has continued to encourage dependence on importation. Some of the reasons for the gap are connected with the improper production methods, scarcity and high cost of inputs, rudimentary post - harvest and processing methods, inefficient milling techniques and poor marketing standards particularly in terms of polishing and packaging as opined by [11].

Theoretically, increase in price of agricultural produce is expected to encourage farmers towards increased production through increased income. This is because, income serves as incentive for further production as farmers are able to procure more improved inputs and manage production risks more efficiently. Similarly, increased rainfall is expected to lead to increased harvest which results in increase in income of farmers. However, the possibility of increased yield through increased prices and adequate rainfall could be affected by several factors. These include low price of farm output, price fluctuations, and limited access of farmers to input and product market or high transaction cost associated with their use. These are likely to deprive farmers of market choices and influence the prices of their produce. Limited market access due to physical constraints such as absence of proper road links or the distances between rural settlement and markets, which limits the marketing of farm produce.

Institutional constraints such as presence of market intermediaries [12] who are involved in sharp practices and get larger share of the profits more than the farmers all serve as disincentive to production, because farmers are discouraged from further production through their inability to save. Moreover, the rapid growing demand for food coupled with seasonal variations, unpredictability and unreliability that characterize the pattern of rainfall in the dry sub - humid and semi - arid agro - ecological zones of Nigeria as a result of climate change has the capacity of limiting farmers to expand production [10].

The presence of these constraints in the Nigerian agricultural production suggests that farmers' response to price changes may be affected to some extent. Other concerns are whether policies put in place are effective or adequate enough to induce positive response from farmers' both in the long and short run. Moreover, erratic changes in the macroeconomic policies coupled with the vagaries of weather could make agricultural prices to be unstable and therefore have unstable effect on agricultural output. Constraints on irrigation and infrastructure due to lack of complementary agricultural policies may also throw farmers into confusion making them to be non responsive to or respond slowly to price incentives.

1.1 Problem Statement

It is obvious that output of most producers in developing countries remain low, due to effects of many factors inclusive of rainfall, yield and prices, perpetuating poverty among producers. There is need to examine the effects of these poverty causing parameters both in the short and long run for appropriate measures, through effective analytical procedures. Emperical work by [13] looked at the relationship between agricultural production and rainfall, however, the work did not examine the influence of prices on agricultural production in the long run. Furthermore [14], also examined the relationship between output of plantain and sweet potatoes, nothing was done on price [15]. looked at the relationship between maize yield and rainfall in Nigeria, using time series data, however, no effort was made to examine the variance property of these variables with time. Furthermore, [16] examined the relationship between urban and rural market prices; the objective of the work was not broad enough to examine the relationship among prices, production and weather variables. Moreover, the analytical perspective of their work made no attempt to investigate the variance property of the data with time (stationarity or non stationarity) of the data employed, leading to the possibility of incorrect inferences should the case exist that some of the variables are non stationary at level. The gaps in knowledge create the need for a wholistic study that examines the relationship among yield, prices of soya bean, rice, maize and rainfall using recent methodologies that take care of the time series property of the data. The study used unit root test, co integration and error correction model which ensure that invalid conclusions associated with the use of ordinary regression model for non stationary variables are taken care of.

1.2 Objective of the Study

The main objective of the study is to establish a long run relationship among poverty related factors in the agricultural industry of developing economics such as yield, prices and rainfall in rice, maize and soya bean. Specifically, the objectives were to describe the level and magnitude of yield, prices of soya bean, rice, maize and rainfall in the study area, determine the existence of long run parameter relationship in rainfall, yield and prices of soya bean, rice and maize in the study area, determine the causal influence of rainfall and prices on the yield of soya bean, rice and maize in the long run, determine the causal influence of rainfall and prices on the yield of soya bean, rice and maize in the short run, evaluate the effect of shocks on rainfall and prices on the variance of yield of soya bean, rice and maize.

2. METHODOLOGY

The study area is Nigeria. Nigeria with a projected population of 160 million, [17] and a total geographical area of 923,768 square kilometers is located between latitudes 4° N and 14° N and longitudes 2°2' and 14° 30' East. Climatically, Nigeria is equatorial in the south, tropical in the centre and arid in the north. Mean maximum temperature ranges from 30-32℃ in the south and 33-35℃ in the north [18]. Nigeria's terrain with rugged hills, undulating slopes, gullies, water logged areas, and flat undulating land surfaces. Specifically, it is characterized by southern lowlands merging into central hills plateaus, mountains in the south east and plains in the north.

Nigeria has a highly diversified agro ecological condition which makes it possible for the production of a wide range of agricultural products. Nigeria has a total land area of about 91.07million hectares, 77% of which is cultivable (agricultural) and 13% under forest and woodland [19]. In terms of employment, at least 60% of Nigeria's projected population of 160 million, is estimated to be engaged or employed in agriculture (mainly small holders).Women make up to 60-80 percent of work or labour and produce two thirds of food crops.

2.1 Sampling Procedure and Data Collection

Thirty six states including Abuja the Federal capital Territory were purposely selected for data collection. Four locations in each state were data collection points for rainfall, yield and prices, for the period of 35 years (1975 - 2009). Data used for the study were mainly secondary comprising output/ yield in metric tonnes per hectare (MT/ha), Nigeria Naira per metric tonne (₦/tonne) for prices and millimeters for rainfall per annum (mm/annum) as annual precipitation. Output/yield data were sourced from Food and Agricultural organization (FAO) Nigeria. Rainfall data were sourced from the National Bureau of Statistics Nigeria.

2.2 Analytical Techniques

Tools utilized were: Augmented Dickey-Fuller (ADF) test, Co integration test, Error Correction Model (ECM) and Granger causality test and Impulse response.

The Augmented Dickey Fuller (ADF) test (Unit Root Test) for the presence of unit root (evidence of non stationarity) was employed. The advantage of the method lies on its robustness to handle both first order and higher order auto regressive processes [20]:

2.3 The Model for Unit Root Test

$$\Delta \mathrm{Y_t} = \alpha + \sigma \mathrm{Y_{t-1}} + \psi \mathrm{T} + \sum_{k=0}^{N} \beta_k \Delta \mathrm{Y_{t-k}} + \mathrm{u_t} \quad (1)$$

Where Y_t represents current values of soya bean, rice and maize yield, Y_{t-i} is the immediate past values of soya bean, rice and maize yield, Δ is the change operator T represents the variable time.

$$\Delta \mathrm{P_t} = \alpha + \sigma \mathrm{P_{t-1}} + \psi \mathrm{T} + \sum_{k=0}^{N} \beta_k \Delta \mathrm{P_{t-k}} + \mathrm{u_t} \quad (2)$$

Where P_t represents current values of soya bean, rice and maize price, P_{t-i} is the past values of soya bean, rice and maize price, Δ is the change operator T represent the variable time.

$$\Delta \mathrm{R_t} = \alpha + \sigma \mathrm{R_{t-1}} + \psi \mathrm{T} + \sum_{k=0}^{N} \beta_k \Delta \mathrm{R_{t-k}} + \mathrm{u_t} \quad (3)$$

Where R_t represents current values of rainfall, R_{t-i} is the past values of rainfall, Δ is the change operator represents the variable time, Where α, β, ψ are parameters to be determined, Y has unit root if in the regression σ = 0; otherwise the unit root does not exist.

In order to ensure that the error term (u_t) in the test model is empirically white noise, the optimum lag order (N) will be chosen where Akaike information criteria (AIC) is minimum within the lag range dictated by [21] l_{12} rule $(\mathrm{Kmax.} = \left(12\frac{\mathrm{T}}{100}\right)^{0.25}$; where T = sample size); Kmax is the maximum lag order permissible for unit root test. Furthermore, the significance of coefficient σ will be tested against the null hypothesis of unit root based on the computed ADF and the tabulated Mackinnon critical values. The decision rule is that if the computed ADF statistic is greater than the critical value at the specified level of significance, then the null hypothesis of unit root is accepted otherwise it is rejected.

2.4 Model for Co Integration Test

Co integration test looks for linear combinations of I (1) time series that are stationary (or, more generally, linear combinations of I(d) time series that are integrated of an order lower than d).[22] co integration method was employed in this study. Johansen Procedure is based on the estimation of Vector Auto Regression (VAR) model transformed into Vector Error Correction Model (VECM) form. If there is co integration we transform the regression to its VECM form, but if there is no co integration we leave it in VAR form.

This procedure focuses on the rank of the Π-matrix (row matrix) as in equation (4)

$$\Delta Z_t = \varphi + \sum_i^p r_I \Delta Z_{t-i} + P_{t-i} + R_{t-i} + \Pi Z_{t-p} + P_{t-p} + R_{t-p} \ldots\ldots + \xi_t \quad (4)$$

Where ΔZ_t is a vector of change in the current value of the endogenous variables under investigation (yield and prices of the rice, maize, soya bean and rainfall); Z_{t-i} are the past values of these variables; Δ is a change operator.

If the Π-matrix has reduced rank but not equal to zero, is a case of co integration implying that Π can be decomposed as αβ. The endogenous variables depicted by Z are co integrated, where α is the matrix of speed of adjustment coefficients which explains the short run effects of changes in the explanatory variable on the dependent variable, whereas β's represent the long run equilibrium effect. However, if the variables are stationary in levels, Π would have full rank.

2.5 Error Correction Model (ECM) and Granger Causality Test

The error correction model was used to model causal influence between non stationary I (1) variables with evidence of long run relationship. The advantage of this procedure lies in the fact that both long run and short run influences of the endogenous variables in the model can be determined with the mechanism that keeps the variable in equilibrium evaluated. For instance, if we hypothesized that variable Y, P and R are jointly determined (i.e. endogenous to a system). Given these conditions and following [23], the relationship between these variables can be described by VAR such that:

2.6 Specification of VAR Model

$$Y_t = \varphi_1 + \sum_{i=1}^p \alpha_{1i} Y_{t-i} + \sum_{i=1}^p \beta_{1i} P_{t-i} + \sum_{i=1}^p \varnothing_{1i} R_{t-i} + \sigma_1 + \xi_{1t} \quad (5)$$

$$P_t = \varphi_2 + \sum_{i=1}^p \alpha_{2i} Y_{t-i} + \sum_{i=1}^p \beta_{2i} P_{t-i} + \sum_{i=1}^p \varnothing_{2i} R_{t-i} + \sigma_2 + \xi_{2t} \quad (6)$$

$$R_t = \varphi_3 + \sum_{i=1}^p \alpha_{3i} Y_{t-i} + \sum_{i=1}^p \beta_{3i} P_{t-i} + \sum_{i=1}^p \varnothing_{3i} R_{t-i} + \sigma_3 + \xi_{3t} \quad (7)$$

where: $\varphi\ and\ \sigma$ are mx1 vector of parameters; α, β are mx1 and m x p vectors of parameters respectively; p is the optimal lag order that minimizes information criteria; m is the number of endogenous variables rainfall and prices of the variable under investigation e.g. rice or maize or soya bean); ξ_{jt} is an mx1 vector of random variables assumed to be normally distributed white noise process.

Suppose we hypothesized further that the series under investigation have unit roots and possibly co integrated, the Granger representation theorem asserts that error correction model (ECM) or restricted VAR of the form:

2.7 Specification of Error Correction Model (ECM)

$$Y_t = \gamma_1 + \lambda_j (Y_{t-1} - \alpha_1 P_{t-1} - \alpha_2 R_{t-1}) + \sum_{i=1}^{p-1} A_{1i} \Delta Y_{t-i+1} + \sum_{i=1}^{p-1} \beta_{1i} \Delta P_{t-i+1} + \sum_{i=1}^{p-1} \Phi_{1i} \Delta R_{t-i+1} + \varepsilon_{1t} \quad (8)$$

$$P_t = \gamma_2 + \lambda_j (Y_{t-1} - \alpha_1 P_{t-1} - \alpha_2 R_{t-1}) + \sum_{i=1}^{p-1} A_{2i} \Delta Y_{t-i+1} + \sum_{i=1}^{p-1} \beta_{2i} \Delta P_{t-i+1} + \sum_{i=1}^{p-1} \Phi_{2i} \Delta R_{t-i+1} + \varepsilon_{2t} \quad (9)$$

$$R_t = \gamma_3 + \lambda_j (Y_{t-1} - \alpha_1 P_{t-1} - \alpha_2 R_{t-1}) + \sum_{i=1}^{p-1} A_{3i} \Delta Y_{t-i+1} + \sum_{i=1}^{p-1} \beta_{3i} \Delta P_{t-i+1} + \sum_{i=1}^{p-1} \Phi_{3i} \Delta R_{t-i+1} + \varepsilon_{3t} \quad (10)$$

Produce consistent estimates of the system parameters. The parameter λ_j in (8), (9) and (10) measures the speed of adjustment of short run disequilibrium to long run equilibrium position; while the parameter A, β and Φ measure the short run temporary influence of the past values of yield on price, past values of prices on yield and past values of rainfall on yield respectively, such that if the coefficient in eqn (8), (9), and (10) are respectively such that,

$$A_{11} = A_{12} = A_{13\ldots\ \ldots\ \ldots} A_{1p-1} = 0$$

$$\beta_{11} = \beta_{12} = \beta_{13\ldots\ \ldots\ldots} \beta_{1p-1} = 0$$

$$\Phi_{11} = \Phi_{12} = \Phi_{13} \ldots\ldots\ldots\ldots \Phi_{1p-1} = 0,$$

Then past values of the variables yield, price and rainfall are said not to Granger cause the current value of yield (Y).

Furthermore, the optimal lag order will be determined by the lag order that minimizes Akaike information criterion (AIC). The Information criterion is based on the model log likelihood and lag length such that:

AIC = – 2(*l/T*) + 2(*k/T*) where l is the value of the log likelihood function; T is the sample size; and K is the number parameters.

Granger causality is based on Wald procedure and makes use of chi statistics which is expressed as:

$$\sum\left(\frac{\beta_1}{s_1}\right)^2 + \sum\left(\frac{\beta_2}{s_2}\right)^2 + \sum\left(\frac{\beta_3}{s_3}\right)^2 + \ldots \sum\left(\frac{\beta_N}{s_N}\right)^2 = (t_1)^2 + (t_2)^2 + (t_3)^2 + \cdots (t_N)^2 \quad (11)$$

$$\sum\left(\frac{\emptyset_1}{s_1}\right)^2 + \sum\left(\frac{\emptyset_2}{s_2}\right)^2 + \sum\left(\frac{\emptyset_3}{s_3}\right)^2 + \ldots \sum\left(\frac{\emptyset_N}{s_N}\right)^2 = (t_1)^2 + (t_2)^2 + (t_3)^2 + \cdots (t_N)^2 \quad (12)$$

Where the *beta* coefficients are associated with prices for soya bean, rice and maize and *Phi coefficients* are associated with rainfall respectively. The t is t-values

2.8 Impulse Response Function

The impulse response function examines dynamic response of a model to a shock. It traces the effect of a one-time shock to one of the innovations on current and future values of the endogenous variables [24]. Proposed that an unrestricted VAR of the form:

2.9 Impulse Response (Shock Model)

$$\mathrm{Y_t} = \sum_{i=1}^{p} A_i Y_{t-i} + \sum_{i=1}^{p} A_i P_{t-i} + \sum_{i=1}^{p} A_i R_{t-i} \;\; U_t \quad (13)$$

(Where $\mathrm{Y_t}$ is a vector of the endogenous variables past values of the yield of maize, rice or soya beans, prices and rainfall), $\mathrm{Y_{t-i}}, P_{t-i}, R_{t-i}$ are vectors of lagged values of the series under investigation, $\mathrm{U_t}$ is a vector of innovations, $\mathrm{A_i}$ is a vector of parameters considered stable has a moving average (MA) representation given by:

$$\mathrm{Y_t} = \sum_{i=1}^{\infty} \Phi_i U_{t-i} \quad (13)$$

$$\mathrm{p_t} = \sum_{i=2}^{\infty} \Phi_i U_{t-i} \quad (14)$$

$$\mathrm{R_t} = \sum_{i=3}^{\infty} \Phi_i U_{t-i} \quad (15)$$

Where:

$$\Phi_i = A_1\Phi_{i-1} + A_2\Phi_{i-2} + A_3\Phi_{i-3} \ldots\ldots A_p\Phi_{i-p}. \quad (16)$$

The parameter Φ_i is the MA coefficient measuring the impulse response to a unit of exogenous innovation. More specifically, Φ_i represents the response of $\mathrm{Y_t}$, $\mathrm{P_t}$, $\mathrm{R_t}$ to a unit impulse from one of the variables in the system occurring i-th period ago.

3. RESULTS AND DISCUSSION

The result of the study revealed that the mean yield of soya bean, rice and maize in Nigeria were 0.52 mt/ha, 1.76 mt/ha, 1.38 mt/ha respectively. The study further showed that average price of soya bean, rice and maize were ₦80, 316.38, ₦95,044.85 and ₦85,140.00 per ton respectively. Average rainfall within the study period averaged 1953.51mm/annum with a standard deviation of 1102.88 as presented in (Table 1). The ADF test of stationarity revealed that rainfall; prices and yield of soya bean, rice and maize were not stationary at level but stationary on first differencing (Table 2). The Johansen Co integration model on the other hand, revealed that a long run equilibrium relationship exist among rainfall, prices and yield of soya bean, rice and maize variables (Tables 3, 4 and 5). The auto correlation test of residual (Tables 9, 10 and 11) further showed that residuals from the chosen model were free of auto correlation problem, Implying that no major determinant in these system of equations has been left out. Further analysis of the long run relationship among these variables using VECM showed that soya bean price has a negative influence (-0.11) on soya bean yield, while variation in rice prices had no significant causal influence on rice yield. The long run influence of maize price on maize yield was positive and significant (0.08) with low magnitude (Tables 6, 7 and 8). The study further showed that rainfall had a significant but negative influence (-0.44,-1.01,-0.21) on yield of soya bean, rice and maize, implying that excessive rainfall in the long run may lead to leaching and surface runoff thereby reducing the yield of crops. The Error Correction terms (The rate of adjustment of short run disequilibrium to long run equilibrium position) for soya bean yield and maize yield had the expected negative sign with coefficients of (-1.31

and -0.95) respectively, implying that there is a fast rate of adjustment. The Error Correction term for rice is (0.02) and does not have the expected negative sign implying a very slow rate of adjustment. The result of Granger causality test showed that none of the variables had short run causal influence on each other (Tables 12, 13 and 14), while the result of impulse response showed that shocks to any of the variables had a persistent effect on the others for more than ten years (Figs. 1, 2 and 3).

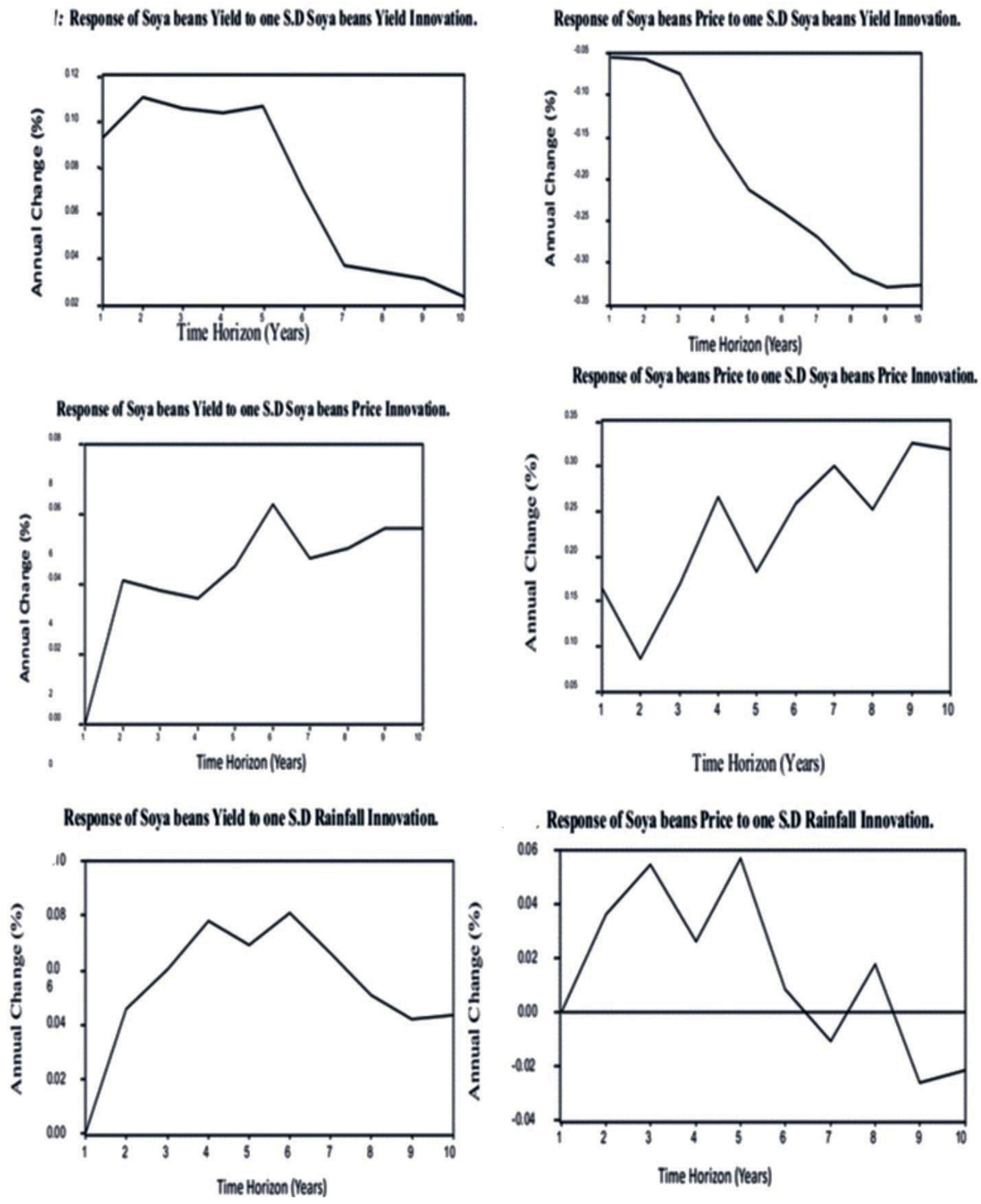

Fig. 1. Impulse response of soya bean yield, soya prices and rainfall in Nigeria

Table 1. Descriptive statistics of yield, prices and rainfall for soya bean, rice and maize in Nigeria (1975-2009)

Item	Soya bean yield mt/ha	Rice yield mt/ha	Maize yield mt/ha	Soya bean Price ₦/t	Rice price ₦/t	Maize price ₦/t	Rainfall (mm)
Max	0.970	2.389	2.200	102,563.40	121,550	92,670	4,046
Min	0.210	1.267	0.971	70,000	71,000	65,000	594
Mean	0.523	1.756	1.387	80,316.38	95,844.85	85,140.00	1,953.51
Median	0.330	1.764	1.320	72,750.00	83,000.00	85,140.00	1,400.00
Std	0.282	0.296	0.266	26,143.63	24,066.31	21,518.02	1,102.84

Source: Prices and Yield Data Adapted from FAO Statistics (1975 – 200 Rainfall Data Adapted from National Bureau of Statistics (1975 - 2009)

Table 2. Augmented dickey fuller (adf) test of stationarity of agricultural yield, prices and rainfall series

Variable	Level				First difference			
	ADF	5%	10%	DW	ADF	5%	10%	DW
Maize Yield	-2.72	-3.55	-3.21	1.89	-5.86(**)(*)	-2.96	-2.62	1.93
Maize Price	-0.83	-2.95	-2.61	2.08	-5.35(**)(*)	-2.96	-2.62	1.96
Rice Yield	-2.78	-3.55	-3.21	1.87	-4.66(**)(*)	-2.96	-2.62	1.98
Rice Price	-1.05	-2.95	-2.61	1.98	-4.66(**)(*)	-2.96	-2.62	1.85
Soya bean yield	-2.44	-3.55	-3.21	2.06	-3.34(**)(*)	-2.96	-2.62	1.97
Soya bean price	-1.14	-2.95	-2.61	2.05	-4.61(**)(*)	-2.96	-2.62	1.89
Rainfall	-1.84	-3.55	-3.21	1.95	-3.88(**)(*)	-2.96	-2.62	1.96

*** (*) significant at (5%) and (10%) respectively source: prices and yield data adapted from FAO statistics (1975 – 2009) rainfall data adapted from national bureau of statistics (1975 - 2009)*

Table 3. Johansen co integration test of long run relationship among soya bean yield, prices and rainfall in Nigeria (1975 - 2009)

Eigen value	Likelihood ratio	Critical value		Hypothesized number of CE(s)
		5%	1%	
0.58	45.43	42.44	48.45	None *
0.30	19.61	25.32	30.45	At most 1
0.25	8.71	12.25	16.26	At most 2

(*) denotes rejection of the hypothesis at 5% significance level L.R test indicates 1 co integrating equation(s) at 5% significance level source: prices and yield data adapted from FAO statistics (1975 - 2009) rainfall data adapted from national bureau of statistics (1975 - 2009)

Table 4. Johansen co integration test of long run relationship among rice yield, prices and rainfall in Nigeria (1975 – 2009)

Eigen value	Likelihood ratio	Critical value		Hypothesized number of CE(s)
		5%	1%	
0.38	26.49	24.31	29.75	None *
0.28	11.13	12.53	16.31	At most 1
0.03	0.82	3.84	6.51	At most 2

(*) denotes rejection of the hypothesis at 5% significance Level L.R test indicates 1 co integrating equation(s) at 5% significance level source: prices and yield data adapted from FAO statistics (1975 – 2009) rainfall data adapted from national bureau of statistics (1975 - 2009)

Table 5. Johansen co integration test of long run relationship among maize yield, prices and rainfall in Nigeria (1975-2009)

Eigen value	Likelihood ratio	Critical value		Hypothesized number of CE(s)
		5%	1%	
0.54	38.13	34.55	40.49	None *
0.34	13.85	18.17	23.46	At most 1
0.03	0.84	3.74	6.40	At most 2

(*) denotes rejection of the hypothesis at 5% significance level L.R test indicates 1 co integrating equation(s) at 5% significance level source: prices and yield data adapted from FAO statistics (1975 -2009) rainfall data adapted from national bureau of statistics (1975 – 2009)

Table 6. The vector error correction model of long and short run relation among soya bean yield, soya bean prices and rainfall in Nigeria (1975-2009)

	Co integrating Eq:	Coint Eql		
Long run model	Soya bean Yield	1.00		
	Soya bean Price	-0.11(21.70)***		
	Rainfall	-0.44(-16.18)***		
	Constant	-4.18		
Short run model	**ECT**	**Soya bean yield model**	**Soya bean price model**	**Rainfall model**
	Δ Coin Eq 1	-1.31(-1.89)***	-2.14(-1.74)*	0.76(0.69)
	Δ Soya bean Yield $_{t-1}$	1.40(2.26)**	1.52(1.39)	-0.56(-0.56)
	Δ Soya bean Yield $_{t-2}$	1.07(1.85)*	1.62(1.59)	-0.01(-0.01)
	Δ Soya bean Yield $_{t-3}$	0.84(1.62)*	1.17(1.27)	0.32(0.39)
	Δ Soya bean Yield $_{t-4}$	0.85(2.12)	0.07(0.10)	1.03(1.59)
	Δ Soya bean Price $_{t-1}$	-0.08(-0.33)	-0.98(-2.42)**	0.36(0.98)
	Δ Soya bean Price $_{t-2}$	-0.35(-1.35)	-0.46(0.98)	0.06(0.13)
	Δ Soya bean Price $_{t-3}$	-0.41(-2.05)**	0.33(0.93)	-0.24(-0.75)
	Δ Soya bean Price $_{t-4}$	-0.26(-2.21)**	0.04(0.20)	-0.10(-0.49)
	Δ Rainfall $_{t-1}$	-0.30(-1.32)	-0.64(-1.62)	-0.38(-1.05)
	Δ Rainfall $_{t-2}$	-0.30(-1.98)*	-0.08(-0.29)	-0.08(-0.34)
	Δ Rainfall $_{t-3}$	-0.17(-1.49)	-0.09(-0.42)	-0.27(-1.46)
	Δ Rainfall $_{t-4}$	-0.07(-0.66)	-0.03(-0.16)	-0.19(-1.17)
	Constant	0.15(1.71)*	0.29(1.89)*	0.02(0.15)

*Determinant residual covariance 3.57E-06 log likelihood 60.44476 Akaike information criteria -1.029651 schwarz criteria 1.072146 figure in parentheses are t-values *** (**) (*) – significant at 1% (5%) (10%)*

Table 7. The vector error correction model of long and short run relation among rice yield, rice prices and rainfall in Nigeria (1975-2009)

	Co integrating Eq:	Coint Eql		
Long run model	Rice Yield	1.00		
	Rice Price	-0.08(-0.36)		
	Rainfall	-1.01(-3.27)***		
Short run model	**ECT**	**Rice yield model**	**Rice price model**	**Rainfall model**
	Coin Eq 1	0.02(1.36)	0.13(3.33)***	0.01(0.18)
	Δ Rice Yield $_{t-1}$	-0.30(-1.53)	-0.45(-0.91)	-0.09(-0.16)
	Δ Rice Yield $_{t-2}$	-0.16(-0.93)	-0.17(-0.39)	0.07(0.15)
	Δ Rice Price $_{t-1}$	-0.08(-1.02)	0.05(2.27)***	0.11(0.53)
	Δ Rice Price $_{t-2}$	-0.13(-1.69)	-0.28(-1.44)	-0.03(0.15)
	Δ Rainfall $_{t-1}$	0.05(0.67)	0.20(1.06)	-0.17(-0.82)
	Δ Rainfall $_{t-2}$	-0.080(-1.04)	0.29(1.60)*	0.13(0.62)

*Determinant residual covariance 2.54E- 05 log likelihood 33.051166 Akaike information criteria -0.565697 schwarz criteria -0.533605 figure in at 1% (10%) parentheses are t-values *** (*) –significant*

Table 8. The vector error correction model of long and short run relation among maize yield, maize prices and rainfall in Nigeria (1975-2009)

	Co integrating Eq:	**Coint Eql**		
Long run model	Maize Yield	1.00		
	Maize Price	0.08(2.31)***		
	Rainfall	-0.21(-4.47)***		
	Trend	-0.02		
	Constant	-8.18		
	ECT	**Maize yield model**	**Maize price model**	**Rainfall model**
Shortrun model	Δ Coin Eq 1	-0.95 (-2.43)***	0.24(0.24)	1.89(2.37)***
	Δ Maize Yield $_{t-1}$	0.55(1.66)*	-0.82(-0.93)	-1.09(-1.62)
	Δ Maize Yield $_{t-2}$	0.10(0.38)	-0.70(-0.99)	-1.53(-2.83)
	Δ Maize Yield $_{t-3}$	0.34(1.21)	-0.78(-1.06)	-0.54(-0.95)
	Δ Maize Price $_{t-1}$	0.08(0.98)	-0.28(-1.29)	-0.30(-1.77)*
	Δ Maize Price $_{t-2}$	0.02(0.24)	-0.36(-1.60)	0.15(0.84)
	Δ Maize Price $_{t-3}$	0.05(0.58)	0.14(0.64)	-0.00(-0.02)
	Δ Rainfall $_{t-1}$	-0.16(-1.57)	-0.38(-1.45)	-0.02(-0.10)
	Δ Rainfall $_{t-2}$	-0.06(-0.58)	-0.02(-0.07)	0.31(1.47)
	Δ Rainfall $_{t-3}$	-0.15(-1.46)	0.19(0.70)	0.10(0.50)
	Constant	-0.07(-1.11)	0.42(2.41)***	-0.01(-0.09)

*Determinant residual covariance 2.05E-05 log likelihood 35.35789 Akaike information criteria 0.234975 schwarz criteria 2.039023 figure in parentheses are t-values *** (*) –significant at 1% (10%)*

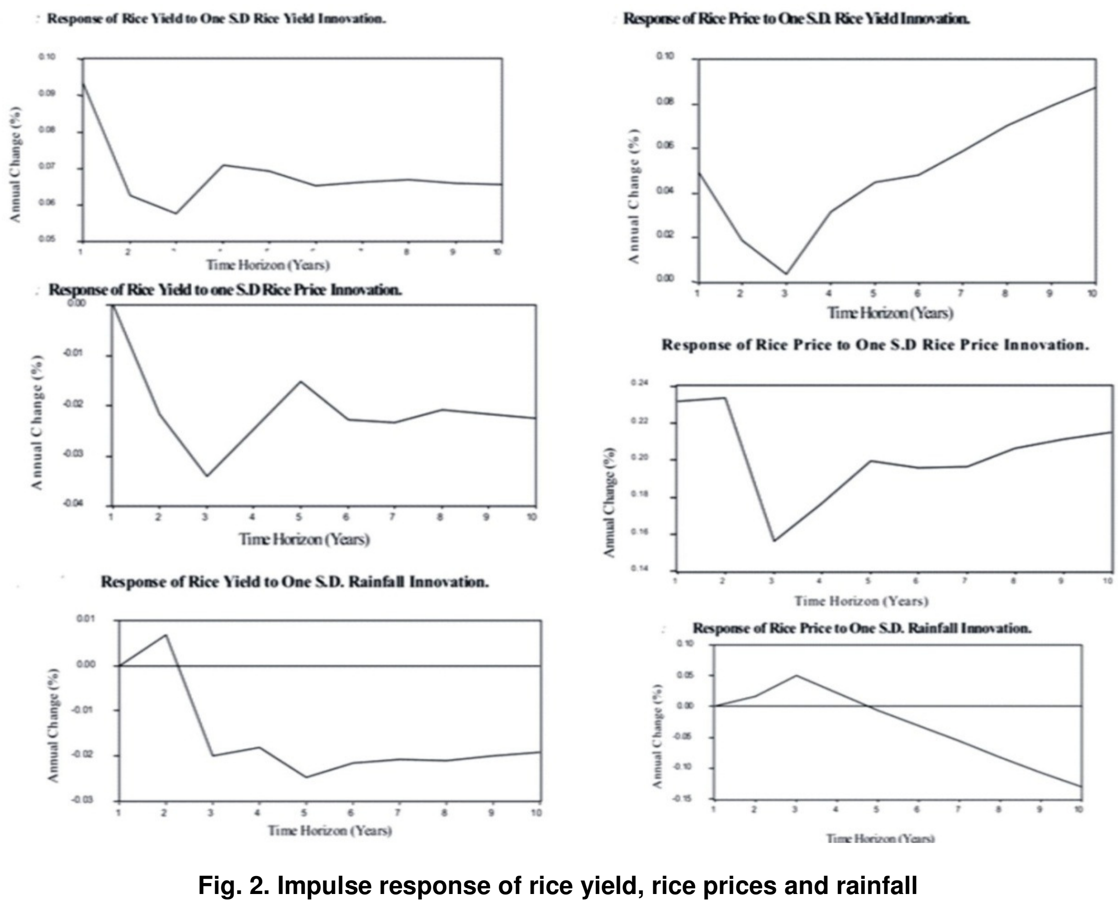

Fig. 2. Impulse response of rice yield, rice prices and rainfall

Table 9. Auto correlation test of residual from ecm of soya bean yield, prices and rainfall in Nigeria

Lag	Autocorrelation coefficient	Partial autocorrelation coefficient	Q-statistic	Probability
1	0.092	0.092	0.2790	0.597
2	0.063	-0.072	0.4139	0.813
3	-0.118	-0.107	0.9112	0.823
4	0.137	0.157	1.6023	0.808
5	0.067	0.025	1.7749	0.879
6	0.213	0.216	3.5863	0.732
7	-0.023	-0.029	3.6091	0.824
8	-0.334	-3.347	8.4777	3.888
9	-0.071	0.030	8.7050	0.462
10	0.197	0.133	10.567	0.392
11	0.065	-0.049	10.784	0.462
12	-0.164	-0.123	12.221	0.428
13	-0.239	-0.202	15.454	0.280
14	-0.151	-0.040	16.817	0.266
15	-0.135	-0.172	17.989	0.263
16	0.114	-0.036	18.876	0.275

Table 10. Auto correlation test of residual from ecm of rice yield, prices and rainfall in Nigeria

Lag	Autocorrelation coefficient	Partial autocorrelation coefficient	Q-Statistic	Probability
1	-0.039	-0.039	0.0530	0.818
2	0.025	0.023	0.0755	0.963
3	0.036	0.038	0.1231	0.989
4	-0.126	-0.124	0.7363	0.947
5	0.145	0.137	1.5842	0.903
6	0.242	0.264	4.0309	0.672
7	-0.147	-0.143	4.9693	0.664
8	-0.139	-0.220	5.8466	0.664
9	-0.195	-0.198	7.6447	0.570
10	0.031	0.112	7.6914	0.659
11	0.067	0.024	7.9259	0.720
12	-0.062	-0.156	8.1365	0.774
13	0.077	0.152	8.4803	0.811
14	-0.375	-0.264	16.980	0.257
15	-0.134	-0.184	18.136	0.256
16	0.097	-0.015	18.772	0.281

Table 11. Auto correlations test of residual from ecm of maize yield, prices and rainfall in Nigeria

Lag	Autocorrelation coefficient	Partial autocorrelation coefficient	Q-statistic	Probability
1	0.033	0.033	0.0382	0.845
2	-0.074	-0.075	0.2288	0.892
3	-0.107	-0.103	0.6482	0.885
4	-0.079	-0.079	0.8854	0.927
5	-0.207	-0.224	2.5731	0.765
6	-0.177	-0.210	3.8510	0.697
7	0.072	0.011	4.0750	0.771
8	-0.061	-0.174	4.2430	0.835
9	-0.154	-0.278	5.3522	0.803
10	0.133	0.010	6.2109	0.797
11	0.084	-0.098	6.5738	0.832
12	0.069	-0.050	6.8301	0.869
13	0.077	0.029	7.1713	0.893
14	-0.070	-0.229	7.4693	0.915
15	-0.000	-0.046	7.4693	0.943
16	0.210	-0.237	10.478	0.841

Table 12. Wald test of short run parameters in ecm of soya bean yield, prices and rainfall in Nigeria (1975 - 2009)

Hypothesis	Calculated chi statistics	Chi^2 statistics tabulated at 5% level of significance
Soya bean yield Granger cause Soya bean yield	15.64	21.23
Soya bean price Granger cause Soya bean yield	11.01	21.23
Rainfall Granger cause Soya bean yield	8.32	21.23
Soya bean yield Granger cause Soya bean price	6.08	21.23
Soya bean price Granger cause Soya bean price	7.72	21.23
Rainfall Granger cause Soya bean price	2.91	21.23
Soya bean yield Granger cause rainfall	2.99	21.23
Soya bean price Granger cause rainfall	1.78	21.23
Rainfall Granger cause rainfall	4.72	21.23

Source: prices and yield data adapted from FAO statistics (1975 - 2009) rainfall data adapted from National Bureau of Statistics (1975 - 2009)

Table 13. Wald test of short run parameters in ecm of rice yield, prices and rainfall in Nigeria

Hypothesis	Calculated chi statistics	Chi^2 Statistics tabulated at 5% level of significance
Rice yield Granger cause Rice yield	3.20	14.05
Rice price Granger cause Rice yield	3.90	14.05
Rainfall Granger cause Rice yield	1.53	14.05
Rice yield Granger cause Rice price	0.98	14.05
Rice price Granger cause Rice price	2.14	14.05
Rainfall Granger cause Rice price	3.68	14.05
Rice yield Granger cause rainfall	0.05	14.05
Rice price Granger cause rainfall	0.30	14.05
Rainfall Granger cause rainfall	1.05	14.05

Source: prices and rainfall data adapted from FAO Statistics (1975 – 2009) rainfall data adapted from National Bureau of Statistics (1975 - 2009)

Table 14. Wald test of short run parameters in ecm of maize yield, prices and rainfall in Nigeria

Hypothesis	Calculated chi Statistics	Chi^2 Statistics Tabulated at 5% level of significance
Maize yield Granger cause Maize yield	4.36	17.79
Maize price Granger cause Maize yield	1.36	17.79
Rainfall Granger cause Maize yield	4.93	17.79
Maize yield Granger cause Maize price	2.96	17.79
Maize price Granger cause Maize price	4.63	17.79
Rainfall Granger cause Maize price	2.59	17.79
Maize yield Granger cause rainfall	11.53	17.79
Maize price Granger cause rainfall	3.84	17.79
Rainfall Granger cause rainfall	2.42	17.79

Source: Prices and Yield Data Adapted from FAO Statistics (1975 – 2009) Rainfall Data Adapted from National Bureau of Statistics (1975 - 2009)

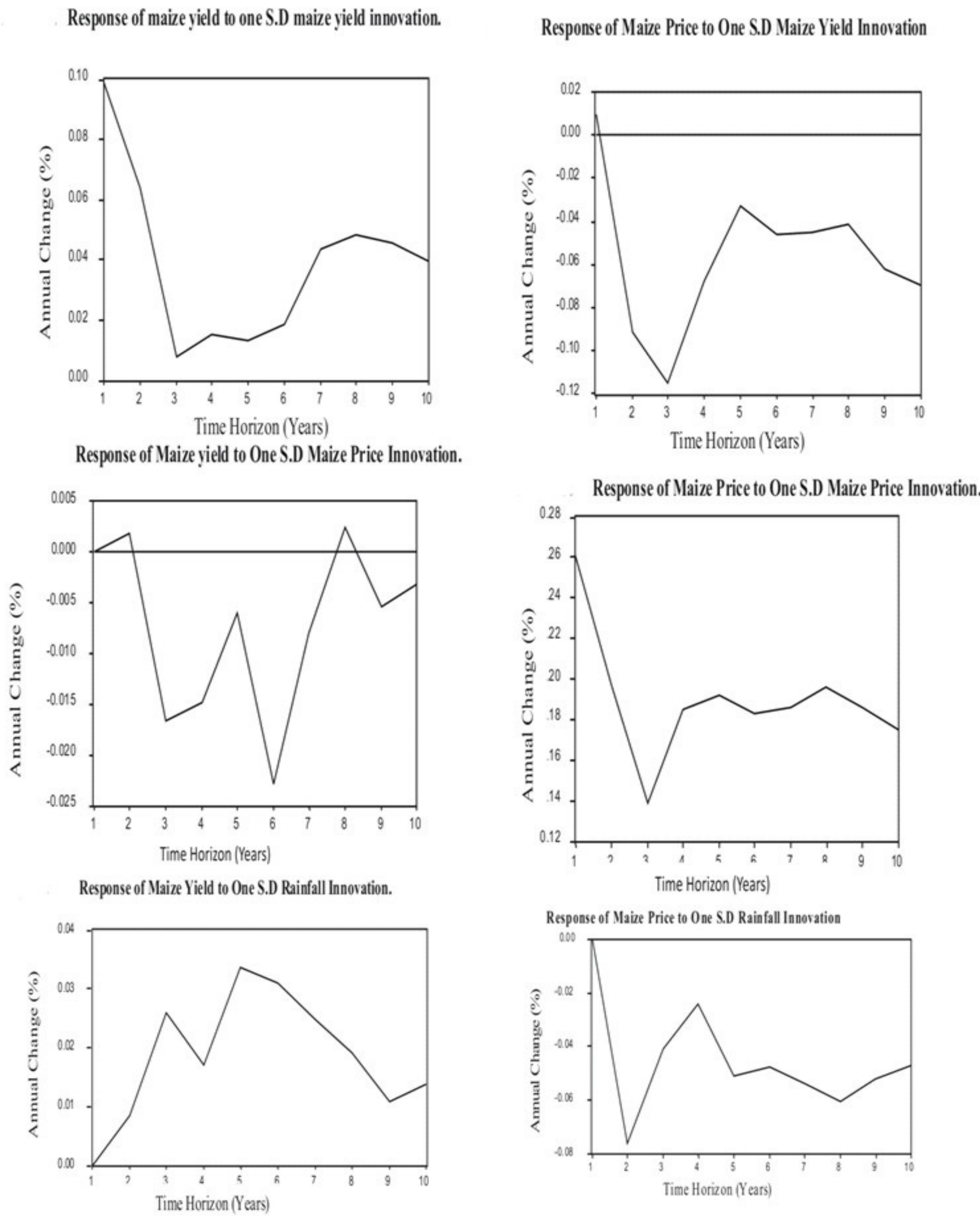

Fig. 3. Impulse response of maize yield, maize prices and rainfall in Nigeria

4. CONCLUSION AND RECOMMENDATION

The study recommends that Co integration model should be adapted for modeling time series data for more effective and efficient results. Efforts should further be intensified to ensure that inputs that increase the yield of rice are available to farmers at affordable prices and as at when due. A more proactive policy measure should be taken on inflation control to forestall its negative influence on agricultural prices and farm level decisions. In relation to marketing, efforts should be made to efficiently organize the marketing of soya bean, rice and maize to ensure that producer prices have positive influence on local producers to stimulate increased output. Efforts such as development of irrigation infrastructure, weather information broadcasting information system and education of farmers on erosion control measures should be intensified to forestall the negative role played by erratic or excessive rainfall due to changes in climatic conditions on farm output.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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