Maize Supply Response to prices in Nigeria: Application of ARDL and Co-integration Analyses

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Abstract

The paper seeks to estimate the response of maize supply to prices in Nigeria. Using both FMOLS and OLS estimators, the empirical findings show that maize supply responds significantly and positively in the long run to own price and negatively (positively) to the price of cassava (yam). Other results reveal that maize supply failed to respond significantly to changes in all the prices in the short run. While the findings show that short-run causality runs only from price of cassava to maize supply, we also find that long-run causality runs from joint effect of the prices to maize supply. The estimated speed of adjustment has negative sign as expected, but very low at 10% level of significance. Meaning that feedback mechanism is slow in converging maize supply towards long-run equilibrium following cumulative shocks/changes in maize supply and prices in the study.

Key words: ARDL, Co-integration, Maize supply, Price elasticity, Nigeria

JEL Classification: C5, O1, Q1

1.0. Introduction

Maize is the most important cereal crop in sub-Saharan Africa (SSA) and an important staple food for more than 874.8 million people in the region. Nigeria is the largest African producer of maize with nearly 8 million tons and an average yield of about 1.5 tons per hectare, which is below the world average of 4.3 tons/ha (FAO, 2012). While the crop is regarded as benchmark for food security after cassava in terms of calorie intake, the major disturbing news is that there is shortage of food grains viz. maize with attendant result of soaring prices in the country (Akanni and Okeowo, 2011).

Broadly speaking, maize production is characterized by a mixed cropping pattern of production system in Nigeria. And, traditionally, maize is often intercropped with crops such as yam and cassava in the country. Meaning that

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domestic maize supply response to own price and prices of other principal staples such as yam and cassava is crucial in explaining the growing gap between the demand and supply of maize in the country ceteris paribus. This observation is held in high esteem by policymakers because responsiveness of farmers to economic incentives such as price could influence contribution of agriculture to economy (Mushtaq and Dawson, 2002).

Since agricultural price policy and price mechanism in supply response play important role in increasing farm production as noted by Nerlove and Bachman (1960), the present paper seeks to estimate the responsiveness of maize supply to own price and prices of major staples such as yam and cassava in Nigeria. As noted by Nkang et al., (2007), measurement of supply responsiveness of farmers is a veritable means of assessing the impact of economic reforms with a view that policies, which provide appropriate incentive such as price or non-price incentives are likely to bring about high supply responsiveness, while those that act as disincentives are less likely to do so. Interestingly, if agricultural supply is highly responsive to price changes, it is likely farmers’ behavior to produce more can be effectively induced increase food production and ensuring long-term food security.

Given this, the objective of the present study as earlier mentioned is to estimate the response of maize supply to prices viz. long run and short run dynamic price elasticities of maize supply in Nigeria. While the former captures long-run price elasticities, the latter sheds lights on the short run price elasticities, speed of adjustment towards long-run equilibrium, and direction of causality. Thus, to address the objective empirically, the study uses co-integration analysis, which incorporates more general dynamic structure than the restrictive popular Nerlovian models often used in agricultural supply response function. Hence, unlike Nerlovian model, the cointegration approach is useful in overcoming the potential problem of spurious regression in supply response function.

A search of literature shows that a considerable number of studies have focused on agricultural supply response to price with wide range of crops over the years
in Nigeria. This includes Garba et al., (1998), Olubode-Awosola et al., (2006); Nkang et al., (2007), Ogazi, 2009; Ajetomobi (2010), and Akanni and Okeowo (2011) to mention a few. Interestingly, many of these studies used co-integration analysis and it implied error correction model instead of the traditional Nerlovian model. But the present study aims to further contribute to the supply response literature in the country in two ways. First, in contrast to the popular Johansen and Engle-Granger techniques used by the aforementioned studies, the present study uses auto regressive distributive lag (ARDL) to investigate the existence of co-integration relationship. Since, small sample size often characterize study of this nature, the use of the Johansen and Engle-Granger techniques for sample size that is less than 80 observations is likely to produce bias results (see, Pesaran et al., 2001; Narayan, 2005 for detail). Second, the present study uses new generation co-integration panel and time series regression estimator such as modified ordinary least square (FMOLS) in comparison with the traditional response function (OLS) to analyze the long run and short run maize supply response to prices in the study. Although, asymptotic distribution of FMOLS and OLS estimators are normally distributed, the results of the two estimators appear mixed. For example, Kao (1999) argued that the bias-corrected OLS estimator such as FMOLS does not improve over the OLS, nevertheless, the author concluded that FMOLS might be more promising in co-integration analysis. While study the finite properties of the OLS and FMOLS estimators in co-integration analysis, Kao and Chiang (2000) found that FMOLS estimator does not improve over OLS. But recent study by Wang et al., (2009) found that FMOLS outperform OLS slightly in co-integration analysis. In view of this development, both the OLS and FMOLS estimators are employed in the present study to further shed light on this inconclusive result in the literature.

The rest of the paper is organized as follows. Section two focuses on the conceptual framework and empirical model, while section three provides detailed descriptive statistics of the data used. Section four presents the results and discussion. Conclusion and policy implication are provided in section five.
2.0. Conceptual framework and empirical models

2.1. Conceptual framework

The estimation of agricultural supply response is based on two identified frameworks viz. Nerlovian expectation model and profit-maximizing approach. While, the former captures the dynamics of agriculture by incorporating price expectations and/or adjustment costs; the later involves joint estimation of output supply and input demand functions (Mythili, 2008). In contrast, to the Nerlovian model, the profit maximizing approach requires detailed information on the quantities and the input prices, which is not available for the present study. Based on this, the present study employed Nerlovian expectation model as a framework for the maize supply response in Nigeria.

As earlier mentioned, the Nerlovian expectation model is a dynamic model, which captures the delay in agricultural production due to resource availability within one or two agricultural production cycles (Nerlove, 1958). Thus, following Nerlovian framework for supply response where desired output ($Y^*_t$) is expressed as a function of price expectation $P^e_t$ in period "t" and defined as

$$Y^*_t = \alpha + \beta P^e_t + \varepsilon_t$$

where, $Y^*_t$ is desired output or a given output, $P^e_t$ is the expected relative prices at period "t"; $\beta$ is the long-run price elasticity of supply, and $\varepsilon_t$ is unobserved random term for the regression.

Furthermore, following the work of Nerlove (1958), the dynamics agricultural supply is expressed as a weight sum of past output, in which the weights decline as one goes back in time and defined as

$$Y_t = Y_{t-1} + \delta (Y^*_t - Y_{t-1}) + \nu_t$$

where, $Y_t$ is the actual output supply; $Y^*_t$ is as defined earlier; $\delta$ is the partial adjustment coefficient and $\nu_t$ is the error/random term for the regression.

Accordingly, the adjustment coefficient "$\delta$" represents the actual change in output between two periods, which also represents a fraction of the change required to achieve the optimal output level $Y^*_t$. If "$\delta$" is close to zero, then it implies that farmers adjustment of actual output to desired output is slow.
Likewise, if "δ" is close to 1, it is an indication that farmers’ adjustment of actual output to desired output is fast. However, in equation 2, we assumed that only information on past prices is taken into account by the economic agents involved in the output supply $Y_t$.

Hence, the structural Nerlovian model represented by equations 1 and 2 when combine yields the reduce form defined as:

$$Y_t = \delta \alpha + (1-\delta)Y_{t-1} + \delta \beta P_t^e + \tau,$$

where, $\tau_t = \epsilon_t + \nu_t$; $\delta \beta$ and $\beta$ are the short-run and long-run price elasticities of supply, respectively; $Y_t$ is the output supply, $Y_{t-1}$ is the lagged value of $Y_t$, $P_t^e$ is the price expectation; $\delta$, $\alpha$, and $\beta$ are the parameters to be estimated, and $\tau_t$ is the error term for the regression.

Since, price expectation are updated from one period to another in proportion, the difference between observed price and expected price levels of the previous period can be defined as (see Nerlove, 1958 for details)

$$P_t^e - P_{t-1} = \beta(P_t^e - P_{t-1}) \Rightarrow P_t^e = \beta P_{t-1} - (1-\beta)P_{t-1}$$

According to Kanwar, (2006), if quasi-rational expectation hypothesis is considered, then equation 4a can be expressed as infinite-order of autoregressive process such as

$$P_t^e = \sum_{i=1}^{\infty} \beta(1-\beta)^{i-1} P_{t-i}$$

where $\beta$ is the adapted price coefficient also know as price elasticity of supply, which ranges $0 < \beta < 1$.

However, substituting equation 4b into 3 gives the reduced form

$$Y_t = \delta \alpha + (1-\delta)Y_{t-1} + \delta \beta P_{t-1} + \tau,$$

Equation 5 shows that output supply $Y_t$ can be expressed as a function of its lagged value included to maintain the dynamics nature of agricultural production as earlier discussed and lagged prices, which include own and cross prices. Theoretically, in case of agricultural supply function, we expect output supply $Y_t$.
to respond to own price with higher output and complementary (or competing) crops with positive (or negative) cross-price elasticities. But equation 3 can also be extended to include control variables other than price such as time trend, variables representing weather such as rainfall etc., policy indicator etc. to capture imperfect information in the variables.

A fundamental methodological weakness of the Nerlove model comes down to the crude decision rule that in each period, a fraction of the difference between $Y_t$ and $Y_t^*$ is eliminated as shown in equation 2. According to Thiele (2000), the Nerlove method assumed a fixed target supply based on stationary expectation. Based on this, the author argue that estimating Nerlove method is unlikely to capture the full dynamics of supply, thus biasing elasticity downwards. An alternative approach to Nerlove method is the use of co-integration analysis and dynamic general equilibrium models as noted by Abdulai and Rieder, (1995) and Thiele, (2000). The former will be used in this paper.

2.2. **Empirical Model**

2.2.1. **ARDL to Co-integration test**

The use of co-integration analysis for output supply response requires that the variables in supply function must have co-integration relationship (Thiele, 2000). However, in recognition of the concern raised in the literature on appropriate technique to investigate the existence of co-integration relationship between pair of series with small sample size and also when variables are not integrated of the same order, we employed the ARDL approach that is based on bound test (see, Narayan, 2005).

Broadly speaking, ARDL offers explicit test for the existence of a unique co-integration vector rather than assuming one, while it also takes into account the possibility of reverse causality (i.e., the absence of weak exogeneity of the regressors) thereby ensuring that the parameter estimates are efficient and consequently valid (Pesaran *et al.*, 2001). Besides, ARDL offers a more significant approach for determining co-integration relationship in small sample, especially when sample size is less than 80 observations, while the Johansen approach and Engle-Granger procedure require large data sample for the purpose of validity.
Also, contrary to Johansen approach, ARDL avoids concerns associated with the large number of choices that must be made. Among these choices are decision regarding the number of endogenous and exogenous variables (if any) to be included, treatment of deterministic element as well as the order of the vector autoregressive (VAR) and the optimal number of lags to be specified. Finally, while Johansen approach and other techniques require that all series to be integrated of the same order, the ARDL overcome this by providing a feasible application on mixed series (see, Pesaran et al., 2001 for details).

To this end, the ARDL used for the study is defined below

$$\Delta \ln Y_t^{\text{maize}} = \alpha_0 + \sum_{j=1}^{k} \omega_j \Delta \ln Y_t^{\text{maize}} + \sum_{j=1}^{k} \gamma_j \Delta \ln P_t^{\text{maize}} + \sum_{j=1}^{k} \delta_j \Delta \ln P_t^{\text{yam}} + \sum_{j=1}^{k} \vartheta_j \Delta \ln P_t^{\text{ cassava}} + \phi_1 \ln P_t^{\text{maize}} + \phi_2 \ln P_t^{\text{yam}} + \phi_3 \ln P_t^{\text{ cassava}} + \eta_t$$

where $\Delta$ is change operator, $\ln$ is the natural logarithm, $k = 2$ and this is the number of lags used, $Y_t^{\text{maize}}$ is maize output supply in tons; $P_t^{\text{maize}}$, $P_t^{\text{yam}}$ and $P_t^{\text{ cassava}}$ are the prices per ton of maize, yam and cassava, respectively; $\omega_j, \gamma_j, \delta_j, \vartheta_j, \phi_1, \phi_2$, and $\phi_3$ are the parameters to be estimated, and $\eta_t$ is the error term of the regression.

From equation 6, the null hypothesis of no co-integration is defined as $H_0: \phi_1 = \phi_2 = \phi_3 = 0$. Hence, the test statistics for the null hypothesis of no co-integration between the maize supply and prices of maize, yam and cassava series in equation 6 is based on a F-statistics or Wald test statistics, while critical value is from bound test developed by Pesaran et al. (2001) for large sample size and later extended by Narayan (2005) to cover studies with small sample size.

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3 The preliminary analysis of time series property of the variables, in particular unit root test, which will be discussed later in the paper shows the variables are not of the same order.

4 The number of lags is guided by the Akaike Information Criterion (AIC)
2.2.2. Co-integration Analysis

As mentioned earlier, the study intends to use co-integration analysis, which does not impose restriction on the short-run behavior of prices and quantities to estimate maize supply response to prices. Since, co-integration analysis only requires co-movement of output supply and the prices in the long run, a typical long-run equilibrium and short run dynamic supply response functions within the framework of co-integration analysis for this study are discussed below.

Long-run equilibrium supply function

The long-run equilibrium supply response function for the study can be expressed as follows

\[
\ln Y_{t}^{\text{maize}} = \tau_0 + \varphi_1 \ln P_{t}^{\text{maize}} + \varphi_2 \ln P_{t}^{\text{yam}} + \varphi_3 \ln P_{t}^{\text{cassava}} + u_t
\]

where, \(\ln\) is the natural logarithm, \(Y_{t}^{\text{maize}}\) is maize output supply in tons; \(P_{t}^{\text{maize}}\), \(P_{t}^{\text{yam}}\) and \(P_{t}^{\text{cassava}}\) are the prices per ton of maize, yam, and cassava, respectively considered as a major determinants of maize supply \(Y_{t}^{\text{maize}}\) in the study.\(^5\)

Short-run dynamics supply function

A typical short run dynamic function for estimating short-run elasticity can be defined using the relationship below

\[
\Delta \ln Y_{t}^{\text{maize}} = \sigma_0 + \sum_{j=1}^{k} \theta_{j} \Delta \ln Y_{t-j}^{\text{maize}} + \sum_{j=1}^{k} \beta_{j} \Delta \ln P_{t-j}^{\text{maize}} + \\
+ \sum_{j=1}^{k} \theta_{j} \Delta \ln P_{t-j}^{\text{yam}} + \sum_{j=1}^{k} \chi_{j} \Delta \ln P_{t-j}^{\text{cassava}} + \zeta ECT_{t-1} + \sigma_t
\]

\(^5\) While we recognized that other non-factors such as biophysical condition viz. rainfall, infrastructure and capita investment can affect agricultural supply; they are not included in the analysis because information on these variables is not readily available. However, we are confidence that since price is a direct policy instrument, the result of this analysis is expected to help policymakers in policy design in the country.
where, $ECT_{t-1} = \hat{u}_{t-1}$ is the error correction term, which is equivalent to the lagged value of the error term from the equation 7; $k=3$ and this is the number of lagged used; $\beta_j$, $\theta_j$, and $\chi_j$ represents short-run price elasticities of supply; $\zeta$ is the coefficient of the error correction term, which denotes the speed of adjustment towards long run equilibrium. The later measures the period of feedback or convergence of maize supply into a long-run equilibrium following changes in maize supply and the prices, and $\sigma_i$ is the error term of the regression.

The Causality Tests

Although, the existence of a long run equilibrium relationship is an indication of causality in at least one direction, it is fundamentally important to test the direction of causality between economic data, especially where there is a strong indication of endogeneity in the series. Thus, from equation 8, the joint significance of the coefficient of lagged prices $\Delta \ln P_{t-j}^{maize}$, $\Delta \ln P_{t-j}^{sum}$, and $\Delta \ln P_{t-j}^{casava}$ provide evidence of short-run causality from the prices to the output supply. Likewise, the F-statistics of the coefficient of error correction term provides evidence of long-run causality from the joint effect of the prices to the output supply. These tests are very important to provide insights to which of the variables Granger cause maize supply ($Y_{t}^{maize}$).

Short-run causality

The underlying null hypothesis for testing whether short-run causality exists is based on joint significance of the lagged coefficient of the prices as

$$H_0^1: \sum_{j=1}^{k} \beta_j = 0 \ (i.e., \text{short runs from } P_{t}^{maize} \text{ to } Y_{t}^{maize})$$

$$H_0^1: \sum_{j=1}^{k} \theta_j = 0 \ (i.e., \text{short runs from } P_{t}^{sum} \text{ to } Y_{t}^{maize})$$

$$H_0^1: \sum_{j=1}^{k} \chi_j = 0 \ (i.e., \text{short runs from } P_{t}^{casava} \text{ to } Y_{t}^{maize})$$

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6 We use a maximum three lags to capture most dynamic adjustment observable in the series. In line with AIC.
**Long-run causality test**

The underlying hypothesis for testing long run causality is based on the significance of the coefficient of the speed of adjustment of equation 8 as

\[ H_0^2 : \zeta = 0 \]

**Strong causality test**

The strong causality test is carried further to examine the joint significance of the short and long run causality on maize supply as

\[ H_0^3 : \sum_{j=1}^{k} \beta_j + \sum_{j=1}^{k} \theta_j + \sum_{j=1}^{k} \chi_j + \zeta = 0 \]

Intuitively, we expect a unidirectional causality from the prices of the staples to maize supply, while reverse causality from maize supply to staple prices does not hold in principle. The parameters of equation 6-11 and unit root tests were carried out using EVIEWS 7.2.

### 3.0. The Data and sources of the data

The study used annual time series data obtained from various edition of annual abstract of statistics of Central Bank of Nigeria (CBN)'s Economic and Financial Review and Statistical Bulletin (CBN several issues). Additional information was also sourced from FAOSTAT data (FAO, 2012). In all, the data used covered 1961-2008 (i.e., 48 observations). Information obtained from these database includes maize supply in tons and own real price per ton in Nigeria currency unit (Naira). Besides, information on real price per ton of yam and cassava was also sourced from the CBN and FAO database for the analysis. Detailed descriptive statistics of the series used in the analysis are presented in table A of the appendix.

### 4.0 Results and Discussion

#### 4.1. Time series property of the data (unit root test)

Generally, the advantage of using co-integration over Nerlovian model in supply response modeling is due to the fact that the technique offers a means of
identifying non-stationary series and hence avoiding spurious regression via co-integration analysis (Abdulai and Rieder, 1995). In other words, the variables in supply response must be co-integrated.

Unfortunately, many economic data are non-stationary and based on this, ordinary least squares (OLS) regression between non-stationary data is likely to give spurious results (Harris, 1995). To this end, we take a closer look at the time series property of the data viz. unit root of the series (maize supply, maize price, yam price and cassava price).

Table 1a and 1b present the result of the unit root test based on ADF and KPSS, respectively. The ADF test is under the null hypothesis of a unit root (I (1)), while the alternative hypothesis is stationarity in the series (I (0)). The KPSS test is under the null hypothesis of stationarity (I (0)), while the alternative hypothesis is unit root in the series (I (1)). The number of the lags is guided by the Akaike Information Criterion (AIC) to ensure that the serial correlation in the series is absent. Hence, the results presented in the tables show that almost all the series are in the same order at the level and first difference, especially when the deterministic is defined as constant.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Determinants</th>
<th>Level</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>t-statistics</td>
<td>CV (5%)</td>
</tr>
<tr>
<td>Maize output</td>
<td>Constant</td>
<td>-3.6383</td>
<td>-2.9252</td>
</tr>
<tr>
<td></td>
<td>Constant + Trend</td>
<td>-1.8978</td>
<td>-3.5085</td>
</tr>
<tr>
<td>Maize price</td>
<td>Constant</td>
<td>-2.9742</td>
<td>-2.9252</td>
</tr>
<tr>
<td></td>
<td>Constant + Trend</td>
<td>-3.1928</td>
<td>-3.5085</td>
</tr>
<tr>
<td>Yam price</td>
<td>Constant</td>
<td>-2.9848</td>
<td>-2.9252</td>
</tr>
<tr>
<td></td>
<td>Constant + Trend</td>
<td>-4.1966</td>
<td>-3.5085</td>
</tr>
<tr>
<td>Cassava Price</td>
<td>Constant</td>
<td>-3.6099</td>
<td>-2.9252</td>
</tr>
<tr>
<td></td>
<td>Constant + Trend</td>
<td>-3.5358</td>
<td>-3.5085</td>
</tr>
</tbody>
</table>

Note: The variables are with maximum of one lag; CV denoted critical value

<table>
<thead>
<tr>
<th>Variables</th>
<th>Determinants</th>
<th>Level</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>LM-statistics</td>
<td>CV (5%)</td>
</tr>
<tr>
<td>Maize output</td>
<td>Constant</td>
<td>0.7055</td>
<td>0.4630</td>
</tr>
<tr>
<td></td>
<td>Constant + Trend</td>
<td>0.1081</td>
<td>0.1460</td>
</tr>
<tr>
<td>Maize price</td>
<td>Constant</td>
<td>0.2597</td>
<td>0.4630</td>
</tr>
<tr>
<td></td>
<td>Constant + Trend</td>
<td>0.1577</td>
<td>0.1460</td>
</tr>
<tr>
<td>Yam price</td>
<td>Constant</td>
<td>0.7661</td>
<td>0.4630</td>
</tr>
<tr>
<td></td>
<td>Constant + Trend</td>
<td>0.0866</td>
<td>0.1460</td>
</tr>
<tr>
<td>Cassava Price</td>
<td>Constant</td>
<td>0.1613</td>
<td>0.4630</td>
</tr>
<tr>
<td></td>
<td>Constant + Trend</td>
<td>0.1340</td>
<td>0.1460</td>
</tr>
</tbody>
</table>

Note: The variables are with maximum of one lag; CV denoted critical value.
4.2. The ARDL test of co-integration relationship

Following the result of the unit root tests, we sought to determine the existence of co-integration relationship between the series. Given this, Table 2 presents the results of the ARDL bound test based on equation 6 for both the FMOLS and OLS estimators with maximum lag of two, no trend and unrestricted intercept with an estimated F-statistics of 5.247 and 5.953 for the OLS and FMOLS estimators, respectively. Both statistics are higher than the upper bound critical value of 5.207 at 5% level of significance obtained from Narayan’s (2005) table. The implication of this is that the null hypothesis of no co-integration between the maize supply, maize price, yam price and cassava price cannot be accepted in the study.

Table 2: Bound test for co-integration

<table>
<thead>
<tr>
<th>Null Hypothesis</th>
<th>F statistics</th>
<th>Critical value bounds: unrestricted intercept and no trend with k=2 and N=45</th>
</tr>
</thead>
<tbody>
<tr>
<td>( H_0 = \phi_1 = \phi_2 = \phi_3 = 0 )</td>
<td>5.247 (OLS)</td>
<td>10% level 5% level 1% level</td>
</tr>
<tr>
<td></td>
<td>5.953 (FMOLS)</td>
<td>I (0) I (1) I (0) I (1) I (0) I (1)</td>
</tr>
<tr>
<td></td>
<td>3.330</td>
<td>4.083 5.207 5.920 7.197</td>
</tr>
</tbody>
</table>

Note: Critical values from Narayan (2005); I (0) and I (1) represent the lower and upper bound critical values, respectively.

4.3. Long-run equilibrium elasticities

Following the evidence of co-integration relationship between the co-integrating vectors, we present in Table 3 the results of long-run price elasticities of maize supply for both the OLS and FMOLS estimators. And the results show that maize supply responds significantly to own price and prices of other staples considered in the analysis. In particular, the estimated elasticities from both the OLS and FMOLS estimators show that 1% increase in price of maize increased maize supply by 0.88% and 0.95%, respectively, which is consistent with standard production theory: a positive supply response to own price. Meaning that both estimators show that the long-run price elasticity of maize supply to own price is inelastic (i.e., less than one). This result perhaps further lends support to the argument in the literature that farmers in the less developed countries respond slowly to economic incentives such as price (Mythili, 2008). Thus, the author outlined 4 major likely reasons for this observation in the developing economies,
which includes constraints on irrigation, limited access to inputs, high transaction cost, or infrastructure to lack of complementary agricultural policies. The implication of this reasoning to the findings of this paper is that pricing policy alone may not be sufficient instrument to enhance maize production in Nigerian.

Also, the results of the price elasticity of maize supply to the prices of other important staples considered in the analysis shows that 1% increase in the price of yam increased maize supply by 1.52% and 2.2% for OLS and FMOLS estimators, respectively. Other results also show that 1% increase in cassava price decreased maize supply by 0.76% and 0.95% for OLS and FMOLS estimators, respectively. Intuitively, a negative (or positive) maize supply response to increase in prices other than own price implied a response to competing (or complementary) crop. In this case, cassava and yam could be considered competing and complementary crops, respectively to maize supply in Nigeria. The implication of this is that any attempt to limit resources devoted to maize production relative to cassava production could lead to fall in cassava supply and vice versa in Nigeria or better still, any increase in real price of cassava could attract Nigerian farmers to shift from maize to cassava production and vice versa.

However, we compared the result of our findings to previous maize supply response from Nigeria, which include Nkang and Edet (2007) with an estimated own price elasticity of 1.5 and Akanni and Okeowo (2011) with an estimated own price elasticity of 0.99. While the former is based on 1970-1998 series, the later is based on 1970-2007 series and the present study is based on 1961-2008 series. Given this, we found that our estimate is significantly not different from Akanni and Okeowo (2011), while it is substantially lower compared to result obtained by Nkang and Edet (2007) probably due to differences in the period of series used in the respective analyses.

Furthermore, we compared the result from this study with estimate from other developing countries, especially in sub Saharan Africa. The result of our search
shows that the long-run price elasticity of maize supply obtained in the present study is far below 1.57 obtained for Zambia by Foster and Mwanaumo (1995).

Table 3: long-run equilibrium elasticities

<table>
<thead>
<tr>
<th>Estimated Coefficients</th>
<th>OLS estimates</th>
<th></th>
<th>FMOLS estimates</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$t_0$</td>
<td>$lnP_{maize}^t$</td>
<td>$lnP_{ym}^t$</td>
<td>$lnP_{casava}^t$</td>
</tr>
<tr>
<td>$\phi$</td>
<td>3.9274</td>
<td>0.8774***</td>
<td>1.5223***</td>
<td>-0.7612**</td>
</tr>
<tr>
<td>Std. Error</td>
<td>2.5050</td>
<td>0.3506</td>
<td>0.3455</td>
<td>0.3272</td>
</tr>
<tr>
<td>Diagnostics</td>
<td>Adj. $R^2$=0.4897; $F$-statistics=16.039</td>
<td>$R^2=0.4113$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Dependent variable is maize produce in tons; Figure in parentheses are the standard error; *, **, *** implies that the estimates are significant at 10%, 5%, and 1%, respectively.

4.4. Short-run dynamics

The result of the short-run dynamics model is presented in Table 4 for both the OLS and FMOLS estimators with three maximum lags. The results from both estimators show that maize supply responds insignificantly in the short run to own price and the prices of other staples considered in the study. But the coefficient of the error correction term ($ECT_{t-1}$), which represents speed of adjustment from both estimators has expected sign and significantly different from zero but very low. For example, the coefficient of $ECT_{t-1}$ of -0.1490 and -0.1344 are obtained from the OLS and FMOLS estimators, which implies that about 15% and 13% deviation of maize supply from long-run equilibrium is corrected in the current period, respectively. The observed slow in speed of adjustment perhaps can be attributed to the fact that in the short run farmers are constrained by factors such as limited access to inputs or high transaction cost, which limit their ability to adjust quickly to price incentives among others. Furthermore, the fact that the estimated speed of adjustment is significant, although at 10% level of significance is also an indication that the feedback mechanism is effective in converging maize supply towards long-run equilibrium after shock in the maize supply and the price factors in the analysis.

4.5. Causality tests

Presented in the lower panel of Table 4 is the result of the causality tests as outlined in equations 9-11 for both estimators employed for the empirical
analyses. Hence, the results of the F-statistics, which represent joint significance of lagged coefficient of the prices of maize, yam, and that of cassava show that maize price and the prices of yam did not Granger cause maize supply, while the price of cassava Granger cause maize supply at 5% level of significance in the short-run. Also, for both estimators, the result of the long run causality test shows that causality runs indeed from joint effect of the prices to maize supply.

The result of strong causality test provides evidence of the joint short and long runs Granger causality to maize supply in the study. Given this, our results show evidence of strong Granger causality from the joint effect of the prices in the short and long runs to maize supply for FMOLS estimator, while this was found insignificant for OLS estimator.

Table 4: Short-run dynamics estimates

<table>
<thead>
<tr>
<th>Variables</th>
<th>Parameters</th>
<th>OLS estimates</th>
<th></th>
<th>FMOLS estimates</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Coefficients</td>
<td>Std. Error</td>
<td>Coefficients</td>
<td>Std. Error</td>
</tr>
<tr>
<td>ΔlnY_{maize}</td>
<td>θ₁</td>
<td>0.1561</td>
<td>0.1775</td>
<td>-0.0464</td>
<td>0.1544</td>
</tr>
<tr>
<td>ΔlnY_{maize}</td>
<td>θ₂</td>
<td>0.2452</td>
<td>0.1704</td>
<td>0.3660**</td>
<td>0.1402</td>
</tr>
<tr>
<td>ΔlnY_{maize}</td>
<td>θ₃</td>
<td>0.1053</td>
<td>0.1647</td>
<td>0.1956</td>
<td>0.1413</td>
</tr>
<tr>
<td>ΔlnP_{maize}</td>
<td>β₁</td>
<td>0.0020</td>
<td>0.2114</td>
<td>-0.0308</td>
<td>0.1844</td>
</tr>
<tr>
<td>ΔlnP_{maize}</td>
<td>β₂</td>
<td>0.1514</td>
<td>0.1837</td>
<td>0.1428</td>
<td>0.1585</td>
</tr>
<tr>
<td>ΔlnP_{maize}</td>
<td>β₃</td>
<td>-0.0214</td>
<td>0.2035</td>
<td>-0.0844</td>
<td>0.1736</td>
</tr>
<tr>
<td>ΔlnP_{yam}</td>
<td>θ₁</td>
<td>0.0576</td>
<td>0.2032</td>
<td>0.0762</td>
<td>0.1896</td>
</tr>
<tr>
<td>ΔlnP_{yam}</td>
<td>θ₂</td>
<td>-0.1014</td>
<td>0.2023</td>
<td>0.1120</td>
<td>0.1825</td>
</tr>
<tr>
<td>ΔlnP_{yam}</td>
<td>θ₃</td>
<td>-0.0313</td>
<td>0.1938</td>
<td>-0.0368</td>
<td>0.1734</td>
</tr>
<tr>
<td>ΔlnP_{cassava}</td>
<td>χ₁</td>
<td>-0.0254</td>
<td>0.1661</td>
<td>-0.0437</td>
<td>0.1431</td>
</tr>
<tr>
<td>ΔlnP_{cassava}</td>
<td>χ₂</td>
<td>0.2144</td>
<td>0.1692</td>
<td>0.2136</td>
<td>0.1478</td>
</tr>
<tr>
<td>ΔlnP_{cassava}</td>
<td>χ₃</td>
<td>0.2769</td>
<td>0.1665</td>
<td>0.2426*</td>
<td>0.1443</td>
</tr>
<tr>
<td>ECT_{-1}</td>
<td>ζ</td>
<td>-0.1490*</td>
<td>0.0809</td>
<td>-0.1344*</td>
<td>0.0745</td>
</tr>
<tr>
<td>Constant</td>
<td>σ₀</td>
<td>-2.6171**</td>
<td>0.9959</td>
<td>-2.3326**</td>
<td>0.8727</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Short run causality test:</th>
<th>F-statistics (p-value)</th>
<th>F-statistics (p-value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>P_{maize} → Y_{maize}</td>
<td>0.2887 (0.8332)</td>
<td>0.5199 (0.6719)</td>
</tr>
<tr>
<td>P_{yam} → Y_{maize}</td>
<td>0.1556 (0.9253)</td>
<td>0.2550 (0.8571)</td>
</tr>
<tr>
<td>P_{cassava} → Y_{maize}</td>
<td>3.0742* (0.0426)</td>
<td>3.1891 (0.0383)</td>
</tr>
<tr>
<td>Long run causality test</td>
<td>3.3889** (0.0755)</td>
<td>3.2518* (0.0817)</td>
</tr>
<tr>
<td>Strong causality test</td>
<td>1.3059 (0.2229)</td>
<td>2.1671** (0.0408)</td>
</tr>
</tbody>
</table>

* Figure in parentheses are the standard error; *, **, *** implies that the estimates are significant at 10%, 5%, and 1%, respectively.
5. Conclusions and Policy Implications

The paper has examined the response of Nigerian maize supply to prices over the period 1961-2008 using OLS and FMOLS estimators. Our findings lend support to the argument of Kao and Chiang (2000) that FMOLS estimator does not improve over OLS estimator as both estimators gave similar results in the study. Hence, the empirical results show that the long-run price elasticity of maize supply to own price is inelastic and significantly different from zero (i.e., less than unity), while the long run price elasticity of maize supply with respect to the prices of yam and cassava shows that these crops could be considered competing and complementary crops, respectively to maize supply in Nigeria. Other results show that in the short run, maize supply responds insignificantly to none of the prices, while the estimated speed of adjustment is negative and very low at 10% level of significance. The later indicates that the feedback mechanism is very slow in converging maize supply towards long-run equilibrium following changes in maize supply and the prices in the study. Although, we find evidence that short run causality runs only from cassava price to maize supply, other results show that long run causality runs from joint effect of the prices to maize supply in the study.

Hence, an important policy implication from the study is that the findings help draw the attention of policymakers to the responsiveness of Nigerian maize supply to long and short-term price adjustments. And, given the low response of maize supply to own price in the long run, non significant of the maize supply to own price in the short run, and low speed of adjustment obtained in the study, it does not necessarily imply that domestic maize supply is unresponsive to maize price. But, it is likely that non-price incentives may be hindering translation of price incentives to stimulate maize supply in Nigeria. This observation is in recognition that non-price factors could dominate price factors in farmers’ decision making process (Mythili, 2008).

In this case, the study suggests a strong commitment to policies that can explore the long-term (not short term) agricultural policy packages with element of price and non-price incentives rather than just pricing reform. Of course, such policy
package is expected to play a key role in promoting a better response from maize producers in Nigeria. However, this could include; irrigation investment, farm equipment services; better access to input markets viz. fertilizer, improved seeds etc., well organized output market, improved road network linking commodity producing areas with major agricultural market centers, well coordinated market information system to help farmers have access to prevailing market prices of major staples, as well as research and agricultural extension services, which is capable of giving higher yields among others.

Acknowledgement

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References


FAOSTAT of Food and Agriculture Organization statistical database. Available @ www.faosta.fao.org


**Appendix**

**Table A: Summary of statistics of the variables used in the analysis**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Unit</th>
<th>Mean</th>
<th>S.D</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize output</td>
<td>Tons (1000)</td>
<td>3209.50</td>
<td>2438.80</td>
<td>488.00</td>
<td>7525.00</td>
</tr>
<tr>
<td>Maize Price</td>
<td>Real Price per ton (Naira)</td>
<td>458.90</td>
<td>142.59</td>
<td>198.53</td>
<td>858.21</td>
</tr>
<tr>
<td>Yam Price</td>
<td>Real Price per ton (Naira)</td>
<td>601.30</td>
<td>198.67</td>
<td>223.42</td>
<td>1162.62</td>
</tr>
<tr>
<td>Cassava Price</td>
<td>Real Price per ton (Naira)</td>
<td>304.13</td>
<td>98.89</td>
<td>126.73</td>
<td>526.88</td>
</tr>
</tbody>
</table>

*Note: Naira is the local currency Unit of Nigeria*