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# Spatial Integration and Price Transmission in Selected Rural and Urban Markets for Cassava Fresh Roots in Nigeria

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**Abstract**

An advanced time series econometric technique was used to study the interaction between the prices of cassava fresh roots in typical urban-demand and rural-supply markets in Nigeria. The price data cover 95 weeks from week 37 of 2004 to week 28 of 2006. The Augmented Dickey-Fuller (ADF) test was used to investigate stationarity in the prices while Johansen cointegration test procedure, with its associated vector error correction model (VECM) was used to measure the speed of adjustment coefficients that characterized the long-run dynamics of the system. Unit root tests revealed non-stationarity in both urban and rural prices series: in levels the ADF-test statistics were calculated as -1.68 for the rural price and -2.69 for the urban price while in first differences they were -13.98 and -11.91 respectively. Cointegration test revealed that both prices were cointegrated with the trace- and maximum eigenvalue statistics calculated as 18.79 and 16.38, each being statistically significant ($p<0.5$). The VECM reveals that any positive deviation from the long-run equilibrium would cause the system to respond with decreases in both the rural and urban prices, albeit the rural price responded faster. The impulse response analysis revealed that the rural price was more responsive to shocks emanating from the rural markets. The effect of the shock was calculated as 63.8% using the forecast error variance decompositions. The effect of rural price shock on the urban price appeared to be very infinitesimal at only 6.0% after about 10 periods. The Granger causality test did not reveal any significant causality link between the rural and urban markets prices, suggesting lack of clear trends in price leadership. The finding reveals the lack of predictability and reliability of markets for highly perishable and susceptible agricultural products, like raw cassava roots. There is need to strengthen cassava value chains with greater emphasis on processing and/or direct sale of roots to commercial processors, so as to reduce the volume of transaction of raw roots in the open market, because of the associated price shocks that have perpetually left the rural Nigerian farmer in abject poverty.

**Keywords:** Cassava fresh roots, spatial integration, rural, urban, markets, price leadership, Nigeria.

## 1. Introduction

Prices are at the center of economic analysis. In fundamental microeconomic theory of the firm, the enterprise is believed to maximize its short-run profit by setting its output and price at the level defined by the interaction of the marginal cost and marginal revenue curves. This popular marginalist principle guides the firm's short-run price and output decisions (Koutsoyiannis, 1979). In the same vein, prices direct the behaviours of consumers in their quest to attain maximum levels of satisfaction through purchase of goods and services in the market. This is because, the decision-making of every rational consumer is aimed at obtaining maximum utility from selection/consumption of goods and services at given market price under budget constraint. Perhaps, the instrumentality of the price variable explains why economists have shown much interest in the relationships among products' prices, notwithstanding that some non-price factors, like product attributes, consumer income, taste, technology, et cetera, to a large extent play good roles in describing and explaining market equilibrium (Asche *et al.*, 2005; Chopak, 1998).

In the food system, prices are signals sent between or among the market participants (Chopak, 1998). Included among the key operators of the food system are input producers and suppliers, farmers, marketing agents, like rural assemblers, transporters, millers, packagers, wholesalers, retailers, and consumers. Specifically, relationships between or among market prices are analyzed within the contexts of agricultural supply chain and market integration analyses (Ojiako and Ezedinma, 2007). Be it in a wholesale or retail trade, prices play vital roles in agricultural value chain discuss, especially for highly perishable commodity like cassava fresh roots. Because of its vulnerable nature, the effect of price shock is usually high and the farmer will be compelled to chose between given out the commodity at a very low price or in an effort to reduce the risk of incurring additional losses, and end. With respect to investigation of relationships between prices in market integration analysis, Asche *et al.*, (2005) observed that there is usually a simultaneity problem, as there is no agreement in economic theory as to the direction of causality.

Nigeria is adjudged the world's largest producer of cassava [*Manihot esculenta* Crantz), with FAO records (FAOSTAT, 2013) revealing a production output of 36.82 million metric tonnes in 2009, which increased by 15.51% to 42.53 million metric tonnes in 2010. The recorded output levels were equivalent of 15.64% and 17.97% respectively of world production during the periods (FAOSTAT, 2013). Cassava maintains the status of a food security crop with over 80% of production being consumed domestically for household food security. After removing the output needed for sustenance of their various homes, farming households would usually release the remainder of their yearly output to the markets for use by other consumers, especially those residing in the urban and semi-urban cities. The destination points might be far or near, but the exit strategy starts from the farm-gate through the local markets, usually situated in the villages or very close to them, and often could involve different channels and networks. A brief description of the trade network for cassava fresh roots presented by Ezedinma *et al*. (2007) showed two major classifications: (a) bulk building and distribution network involving rural assembly market and destination market; and (b) network involving feeder and urban markets. The first could be broken into trade routes linking rural assembly markets, which receive roots supplies from farmers and distribute to other markets, and routes linking rural markets, which might serve as either assembly or feeder markets to other markets, usually located in the city centers. The second might include rural-urban distribution network involving nearby markets or that linking distant markets. Due largely to the bulky and perishable nature of cassava, the link between nearby markets happened to be the most popular. According to Ezedinma *et al*. (2007), it involves the movement of roots from the surrounding feeder markets in the cassava-producing rural areas to the adjoining urban markets. Expectedly, the size and proximity of the urban fresh roots market, and the price margin assist to attracting large quantities of fresh roots from several directions to urban areas.

Whichever route it passes, the price element is instrumental in the study of interaction and relationships among cassava product markets, as it is for the entire the food demand and supply chain (Ojiako and Ezedinma, 2007). Among the functions performed by prices are that they help to express value of products, provide information on products' level of supply in the market, provide information on the marketing agent's perception of the products' future supply and demand, and act either as an incentive or a disincentive for trade and production (Chopak, 1998). Other things being equal, it is expected that if the market of a product is efficient, variations in the product's prices in a typical rural source market will be followed by similar variations in price in urban destination market. By implication, prices that move together are expected to share a long-run equilibrium relationship (Banerjee *et al*., 1993).

The general objective of this paper is to investigate the interaction between the prices of cassava fresh roots in typical urban-demand and rural-supply markets in Nigeria. The specific objectives are: (a) to examine the trend in the rural-supply and urban-demand markets prices; (b) to determine the time series properties of the prices; (c) to investigate existence or non-existence of linkages between markets prices; and (d) examine the direction of price leadership in fresh roots' markets. It is expected that the finding from this investigation would assist in the formulation and implementation of price policies that would lead to efficient in the agricultural products markets in general and perishable products in particular.

## 2. Materials and Methods

### 2.1 Study area

The data used for this study were obtained from the records of the market information services (MIS) unit of the Integrated Cassava Project (ICP), International Institute of Tropical Agriculture, Ibadan, Nigeria. The unit has documented the weekly market prices for over twenty agricultural commodities, including those of the major cassava products, from over 50 urban and rural markets across Nigeria. These were made available on the official website http://www.cassavabiz.org since 2004. Price data covering 95 weeks, from week 37 of (September) 2004 to week 28 of (July) 2006 were used for the study. Fresh cassava roots were investigated. Rapid appraisal of the cassava products' markets in Nigeria had shown that most traders from Lagos State often obtained the cassava products from different rural markets across the various states of Nigeria. Specifically, it was observed that over 60% of the cassava fresh roots from a Kila community Market, a rural assembly market in south-west of Nigeria were being supplied to traders from the popular Mile 12 urban market in Lagos State (Ezedinma *et al*., 2007). The Kila Markets is located at latitude 07.36698$^{o}$ N and longitude 03.66283$^{o}$ E along the old Ibadan-Abeokuta Road in Odeda Local government Area of Ogun State, Nigeria. The Mile 12 Market is located at latitude 06.60886$^{o}$ N and longitude 03.35056$^{o}$ E in Isheri-Ikosi LGA of Lagos State, Nigeria. The trends in weekly prices of fresh cassava roots for the rural source and urban destination markets are presented in Figure 1.

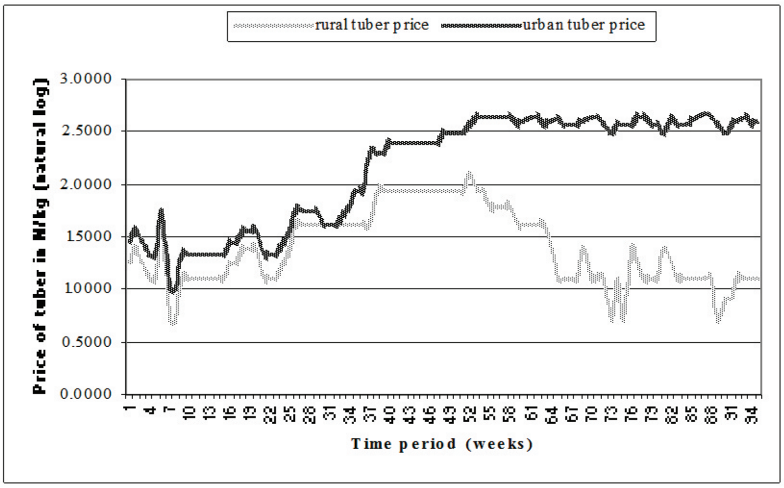


Figure 1: Trends in urban and rural markets' prices of cassava fresh roots

**2.2 Analytical techniques**

The analytical tools used in this study include descriptive statistics, correlation analysis, based on the Pearson's product moment correlation coefficient, cointegration and its associated vector error correction model, Granger causality test, impulse response analysis, and forecast error variance decomposition analyses.

*2.2.1 Conceptual cointegration and error correction specification*

In this study the technique of cointegration, which describes existence of long or equilibrium relationships (Goodwin and Holt, 1999; Tambi, 1999; Silvapulle and Jayasuriya, 1994; Goodwin and Schroeder, 1991), and its associated error correction representation was used to study the behavior of urban and rural roots prices. Equilibrium relationship implies that the prices move together such that any short-term disturbances from the long-run trend can be corrected (Manning and Adriacanos, 1993). Absence of cointegration implies in principle that the prices wander arbitrarily far away from other (Dickey *et al*., 1991). Cointegration analysis is only appropriate for non-stationary series.

Engle and Granger (1987) and Granger (1981) provided the appropriate stationarity test – the augmented Dickey-Fuller (ADF) statistics, based on the t-statistics associated with "*b*" from the estimation of the ordinary least square (OLS) regressions given as

$$\Delta X_t = a + bX_{t-1} + u_t \qquad (1)$$

$$\Delta X_t = a + bX_{t-1} + \sum_{i=1}^{k} c_i \Delta X_{t-i} + u_t \qquad (2)$$

where $X_t$ is individual price variable; $\Delta X_t=(X_{t+1}-X_t)$; a, b and c are unknown parameters, $u_t$ is error term, and k is the lag length chosen for ADF to ensure that $u_t$ is empirical white noise. The hypothesis of nonstationarity, or unit root ($b = 1$) will be accepted at 0.01 or 0.05 levels if the ADF statistic is greater than the critical value of -3.50 or -2.89 for a model with only intercept and -4.06 or -3.46 for a model with intercept and trend.

This study used the Johansen cointegration procedure. The general form of the Johansen's model estimated for the rural and urban prices of cassava roots is presented as follows:

If $X_t$ denotes an $n x 1$ unrestricted vector autoregression (VAR) in the levels of the non-stationary *I(1)* prices being considered, then:

$$X_t = \mu + a_1 X_{t-1} + a_2 X_{t-2} + \cdots + a_p X_{t-p} + E_t$$
$$= \mu + \sum_{i=1}^{p} a_i X_{t-i} + E_t \quad , \qquad (3)$$

where $X_t$ is an *px1* vector of prices; $X_{t-i}$ is an *px1* vector of the ith lagged values of $x_t$; $\mu$ is a *px1* vector of constants; $a_i$ is a *pxp* matrix of unknown coefficients to be estimated; $p$ is the lag length; and $E_t$ is a *px1* vector of identically and independently distributed error terms with zero mean and contemporaneous covariance matrix, $E(E_tE_t)=\Omega$. Necessary transformation of equation (3) results to:.

$$\Delta X_t = \mu + \zeta_1 \Delta X_{t-1} + \cdots + \zeta_{p-1}\Delta X_{t-(p-1)} + \Pi X_{t-p} + E_t = \mu + \sum_{i=1}^{p-1}\zeta_i \Delta X_{t-i} + \Pi X_{t-p} + E_t \qquad (4)$$

where $\zeta_1 = -(1-\sum_{j=1}^{i} a_j)$, for j=1,2, …, p-1; $\prod = -(1-\sum_{i=1}^{p} a_i)$; and $\Delta X_{t-1} = (pxp)$ vector of $X_{t-1}$ in first differences, for i = 1,2, …, p-1; all other variables are as previously defined.

It follows that the VAR (p) has been transformed into an ECM (p) with an error correction component, $\prod X_{t-p}$.
The matrix $\prod$ is of primary interest in equation (4) for two main reasons:
The rank of $\prod$, $rank(\prod)$, is used to determine existence or otherwise of cointegration or long-run relationships between the variables – if the $rank(\prod)=0$, the variables are not cointegrated and the model is equivalent to a VAR in first difference; if $0 < rank(\prod) < n$, the variables are cointegrated; and if $rank(\prod)=n$, the variables are stationary and the model is equivalent to a VAR in levels (Chang, 2000);
The $\prod$ represents a product of two matrices $\alpha$ and $\beta$ or ($\prod = \alpha\beta'$), where $\beta$ is the matrix of the cointegrating relationship. If $\beta' X_t = 0$, the system is in equilibrium; otherwise, $\beta' X_t$ is the deviation from the long-run equilibrium, or the equilibrium error, which is stationary in a cointegrated system (Johansen and Juselius, 1990; Johansen, 1988). The $\alpha$ is the matrix of speed of adjustment coefficients that characterizes the long run dynamics of the system. If $\alpha$ has a large value, the system will respond to a deviation from the long-run equilibrium with rapid adjustment. Contrarily, if it has a small value the system will respond with slow adjustment to a deviation from the long-run equilibrium. At times the value of $\alpha = 0$ for some system equations imply that the corresponding variable is weakly exogenous and does not respond to equilibrium error. At least one $\alpha$ must have a non-zero value in a cointegrated system (Chang, 2000).

In view of the aforementioned concept, Johansen Maximum Likelihoods procedure for testing for cointegration was proposed (Johansen and Juselius, 1990; Johansen, 1988). The procedure involves pre-testing the order of cointegration in individual series, determining the lag length for the ECM; and estimating the ECM and determining the rank of $\prod$. The presence of a cointegrating relation would form the basis of the VEC specification.

*2.2.3 Empirical model*
For this study we hypothesize that both the rural and urban markets prices of cassava *roots* are jointly determined or endogenous to the system. Following Sims (1980), we can give an implicit representation of the model with two endogenous variables without an exogenous variable as

$$X_t = (\ln\_RP_t,\ \ln\_UP_t) \qquad (5)$$

where $X_t$ is as earlier defined, $ln\_RP_t$ and $ln\_UP_t$ are natural logarithm values of the rural and urban market prices of *roots*. Given the VECM of equation (5), the long-run cointegrating equation can be specified explicitly for the rural market as

$$\ln\_RP_t = \varphi_0 + \varphi_1 \ln\_UP_t + v_t \qquad (6)$$

where $\varphi_0$, the log of a proportionality coefficient, is a constant term capturing the transportation and other forms of cost; $\varphi_1$ is a long run static coefficient depicting the relationship between the urban and rural market prices; and $v_t$ is the random error term with the standard assumptions. If $\varphi_1$=0 there is no relationship between the urban and rural market prices; if 0< $\varphi_1$ <1 there is a relationship but the relative price is not constant, meaning that the goods will be imperfect substitutes; if $\varphi_1$=1 there is relationship with constant relative price, meaning that the "Law of One Price" holds and goods are perfect substitutes. Equation (6) describes a case where prices adjust immediately. If however, a dynamic adjustment pattern is expected in prices, it will be accounted for by introduction of lags of the two prices, but even at that, the long-run relationship between prices will take the same form depicted in equation (6) above (Asche *et al*., 2005).
Upon the establishment of the existence of cointegration between the price series, the VECM will be estimated as:

 

$$\Delta RP_t = \psi_{10} + \sum_{i=1}^{p} \psi_{11i} \Delta RP_{t-i} + \sum_{i=1}^{p} \psi_{12i} \Delta UP_{t-i} - \rho(RP_{t-1} - UP_{t-1}) + v_{1t} \quad (9)$$

$$\Delta UP_t = \psi_{20} + \sum_{i=1}^{p} \psi_{21i} \Delta RP_{t-i} + \sum_{t=1}^{p} \psi_{22i} \Delta UP_{t-i} - \rho(RP_{t-1} - UP_{t-i}) + v_{2t} \quad (10)$$

where $RP_t$ *and* $UP_t$ are rural and urban *root* prices earlier defined, $\Delta$ is the difference operator, $\psi_{10}$ and $\psi_{20}$ are constants, $\psi_{11}$ and $\psi_{22}$ are the short-run coefficients, $\rho$ is the error-correction instrument measuring the speed of adjustment from the short-run state of disequilibrium to the long-run steady-state equilibrium; and $v_t$ is an error term assumed to be distributed as white noise.

*2.2.4 Causality tests*

The Granger causality tests are useful in measuring the predictive ability of time series models (Luis, 2005). A time series, $Y_t$, "Granger causes" another series, $X_t$, if present values of $X_t$ can be better predicted by including, among other variables, the past values of $Y_t$ rather than not including it (Luis, 2005). In our case, this can be formally stated as saying that urban market price ($UP_t$) Granger causes the rural market price ($RP_t$) of roots, if the value of $\alpha_i$ in the following equation is different from zero.

$$RP_t = \alpha_0 + \sum_{i=1}^{m} \alpha_i UP_{t-i} + \sum_{j=1}^{m} \beta_j RP_{t-j} + e_t \quad (11)$$

The variables are as previously defined. To prove the existence of causality, an F-test, which is equivalent to the Wald Test, is used. It is expressed as

$$F_{UP_t \to RP_t} = \frac{(SSE_r - SSE_u)/m}{SSE_u/(n-2m-1)} \sim F_{[m,\,(n-2m+1)]}(\alpha) \quad (12)$$

where $SSE_r$ is the sum of squared errors of equation (11) with restricted coefficients of lagged $UP_t$ (that is to say that coefficients are set to zero); $SSE_u$ is the sum of squared errors of the unrestricted form of the equation, $\alpha$ is the critical value; $n$ is the number of observations; and $m$ is the number of lags. The number of lags used in our test is two. If $F_{(UP_t \to RP_t)}$ is less than $F_{[(m,\,n-2m+1)]}(\alpha)$, $UP_t$ does not Granger cause $RP_t$; otherwise it does. If it holds true from the tests that the $UP_t$ Granger causes the $RP_t$ and also $RP_t$ Granger causes the $UP_t$, it reflects a feedback relationship between the urban and rural prices of *roots*.

*2.2.5 Impulse response and error variance decomposition analyses*

The VECM estimation is used to calculate the elements of the impulse response function (IRF) and the error variance decomposition. The functions are used to conduct simulations in which one of the variables is shocked and the response of each of the other variable(s) is traced over a given number of time periods (Shellman, 2004). An impulse response function traces the effect of a one-time shock to one of the innovations on current and future values of the endogenous variables. A shock associated with a particular variable, does not only directly affect it but also transmits to all other endogenous variables through the dynamic or lag structure of the VAR (Luis, 2005). To interpret the response as a percentage change, one has to multiply the impulse responses by one hundred (Krusec, 2003). By tracing the effect and persistence of one market price shock to another market the IRF shows how fast information is transmitted across markets.

The IRF is used to trace the impact of the shock in a variable unto the VECM system in a time period, making it possible to measure how rapidly information is transmitted across the markets. In particular, an impulse response function traces the effect of one unit standard deviation shock to one of the innovations (error terms) and its impact on the current and future values of the endogenous variables (Luis, 2005). The impulse responses are the dynamic equivalents of the elasticity coefficients (Luis, 2005; Fernando, 2003). On its part, the forecast error variance decomposition provides information on the relative importance of each random innovation in affecting the variables in the VECM (Luis, 2005). It helps to separate the variation in an endogenous variable into the component shocks of the model.

All estimates were obtained using the Standard Version of Eviews econometric software. EViews implements VAR-based cointegration tests using the methodology developed in Johansen (Johansen, 1991; 1995; 1988).

## 3. Results and Discussion

### 3.1 Descriptive statistics of products' prices

The descriptive statistics of roots' prices are presented in Table 1 for the urban and rural markets.

Table 1: Descriptive statistics of the cassava roots' prices in levels

| Rural (n=95) | | Urban (n=95) | | Difference | t-value |
|---|---|---|---|---|---|
| Mean (Naira/kg)+ | Std Dev. | Mean (Naira/kg)+ | Std. Dev. | (Naira/kg)+ | |
| 4.30 | 1.613 | 9.69 | 4.172 | 5.39*** | 11.74 |

***=Significant at 1%; **=Significant at 5%
+ Exchange rate of the Nigerian Naira (₦) to the United States Dollars ($) was ₦123.00/US$1.00

It shows that the average urban market price was higher than average rural market price. The mean differences calculated to be NGA₦5.39 were also statistically significant at 1%, which was expected and could be a reflection of the extra costs, including transportation and transactions, incurred by the marketing agents, as well as marketing margins. As Chopak (1998) succinctly argued, the high cost of transactions and risk to invested capital could provide a justification for the margins of the marketing agents.

### 3.2 Times series properties of products prices – tests for unit roots

The results of the ADF unit roots tests are presented in Table 2. It revealed that the null hypothesis of the presence of unit roots could not be rejected. The calculated ADF statistic was less than the critical ADF values at both 5% and 1% levels of significance.

Table 2: Stationarity tests: Augmented Dickey-Fuller unit roots tests for urban and rural roots prices

| Market type | Market location | ADF$^{\alpha}$ statistic | | | |
|---|---|---|---|---|---|
| | | Tests at levels | | Test at first differences | |
| | | Intercept only | Intercept and trend | Intercept only | Intercept and trend |
| Rural | Benue State | -1.681 | -1.765 | -13.981*** | -13.927*** |
| Urban | Lagos State | -1.312 | -2.166 | -11.914*** | -11.858*** |
| ADF Test Critical values (5%) | | -2.893 | -3.459 | -2.893 | -3.459 |
| ADF Test Critical values (1%) | | -3.501 | -4.059 | -3.502 | -4.059 |

***=Significant at 1%; **=Significant at 5%.; the null hypothesis of unit root (Ho: $a_1=1$) could not be rejected because the calculated ADF statistic exceeded the critical ADF (-2.89 for the 95% confidence levels. Default maximum lag provided by the Standard Version of Eviews was used for all tests. The lag lengths in the ADF test were based on the Schwartz Information criterion (SIC).

At the first difference the calculated ADF statistic was higher than the critical ADF-statistic at 5% and 1% levels for both the model with intercept only and for the model with intercept and linear trend. It revealed that the urban and rural prices were nonstationary in levels but stationary in first differences. They were both integrated of order one, I(1) and conform for cointegration test analysis.

### 3.3 Johansen's tests of cointegration

The Johansen's Maximum Likelihood method of cointegration testing procedure, which used the trace and the max-eigen value test statistics to determine the rank of the long-run matrix Π of the error correction instrument, was used and reported in Table 3.

Table 3: Pair wise cointegration tests results between rural and urban market prices of roots

| Hypothesis | Lag interval | Trace statistic | 5% Critical value | 1% Critical value | Max eigen-value statistic | 5% Critical value | 1% critical value |
|---|---|---|---|---|---|---|---|
| $r = 0$ | 1 to 16 | 18.790** | 15.41 | 20.04 | 16.383** | 14.07 | 18.63 |
| $r \leq 1$ | | 2.407 | 3.76 | 6.65 | 2.407 | 3.76 | 6.65 |

***=Significant at 1%; **=Significant at 5%.

Each of the Trace (18.79) and Max eigen-value (16.38) statistic indicates the existence of one cointegrating relation at 5% significant level for urban and rural prices of fresh roots. The cointegrating graph was presented in Figure 2.

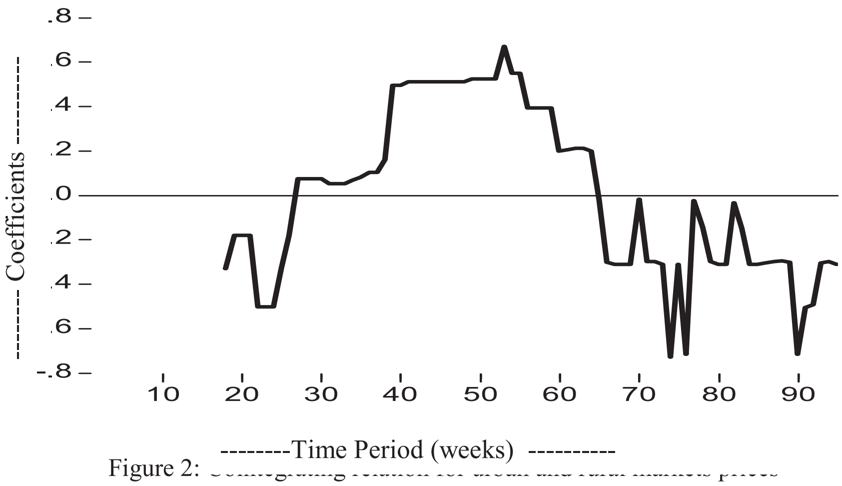

Figure 2: Cointegrating relation for urban and rural markets prices

Because the prices are cointegrated, it was expected that the system could respond to exogenous shocks and return to equilibrium in the long-run. Consequently, the next step was to conduct the vector error correction modeling (VECM).

**3.4 Analysis of the vector error correction modeling (VECM)**

The VECM that includes one cointegrating equation was estimated for the pair of rural and urban markets' prices of roots and reported in Table 4.

Table 4: Vector error correction estimates for urban and rural prices of fresh roots

| Cointegrating Equation | RP | UP |
|---|---|---|
| | 1.0000 | 0.1550 |
| | | ( 0.8055) |
| Constant | -1.8066 | |
| Error Correction | ΔRP | ΔUP |
| CointEq1: | -0.2657*** | -0.0178 |
| | (-3.1846) | (-0.4213) |
| ΔRP(-1) | -0.2972** | 0.0633 |
| | (-2.10320) | ( 0.8868) |
| ΔRP(-2) | 0.0189 | 0.0287 |
| | ( 0.1245) | ( 0.3729) |
| ΔRP(-3) | -0.2591 | -0.1186 |
| | (-1.6967) | (-1.5376) |
| ΔUP(-1) | 0.5523 | -0.0652 |
| | ( 1.8108) | (-0.4234) |
| ΔUP(-2) | 0.7853** | 0.1502 |
| | ( 2.6034) | ( 0.9855) |
| ΔUP(-3) | 0.2927 | 0.0517 |
| | ( 0.9195) | ( 0.3216) |
| Constant | -0.0954** | 0.0118 |
| | (-2.6324) | ( 0.6462) |
| R-squared | 0.5498 | 0.4588 |
| F-statistic | 1.6262 | 1.1301 |
| Log likelihood | 61.7192 | 114.9673 |

***=Significant at 1%; **=Significant at 5%.

Note: RP=Price of cassava roots for the rural market; UP=Price of cassava roots in the urban market (both prices entered the model as natural log values of Nigerian Naira prices)

The speed of adjustment is determined by the long-run parameter estimates or estimated adjustment coefficients given as -0.2657 and -0.0178 for rural and urban markets' prices equations. The implication is that any positive deviation from the long-run equilibrium will cause the system to respond with decreases in both the rural and urban prices. The adjustment coefficients (-0.2657 for RP and -0.0178 UP) indicate that the rural price appears to respond faster relative than the urban price. The adjustment coefficient is statistically significant at 1% RP but not significant for the UP. Elsewhere, similar studies for processed dry matter products, *garri* and *lafun* (Ojiako et al., 2013; 2012), revealed significant adjustment coefficients for both rural and urban markets' prices.

### 3.5 Granger causality tests

The output of the Granger causality test, which is used to measure the predictive ability of the time series model following Luis (2005), is reported in Table 5. It reveals that the null hypothesis that the rural market price of roots (RP) does not "Granger cause" the urban market price (UP) could not be rejected at any significant level, and so also is the hypothesis that the UP does not "Granger cause" the RP. This means failure to establish any causality relationship between the urban and rural prices. It suggests that other non-price variables could have accounted for the markets adjustment, which corroborates with the VECM results.

Table 5: Pair-wise Granger Causality test for cassava roots

| Null hypothesis | Obs. | F-value | Prob. |
|---|---|---|---|
| UP does not Granger cause RP | 93 | 1.468 | 0.236 |
| RP does not Granger cause UP | 93 | 0.148 | 0.823 |

$^{***}$=Significant at 1%; $^{**}$=Significant at 5%, lag length=2

### 3.6 Impulse response analysis

The impulse responses mirror the coefficients of the moving average representation of the VEC model and track the effects of a shock on the endogenous variables at a given point in time. The coefficients of the impulse responses based on Cholesky's decomposition are presented calculated and the trends presented in Figure 3 for periods 1-10. It coefficients can be interpreted as the response of the rural or urban prices series of roots to a one standard deviation shock originating from itself and from the urban price.

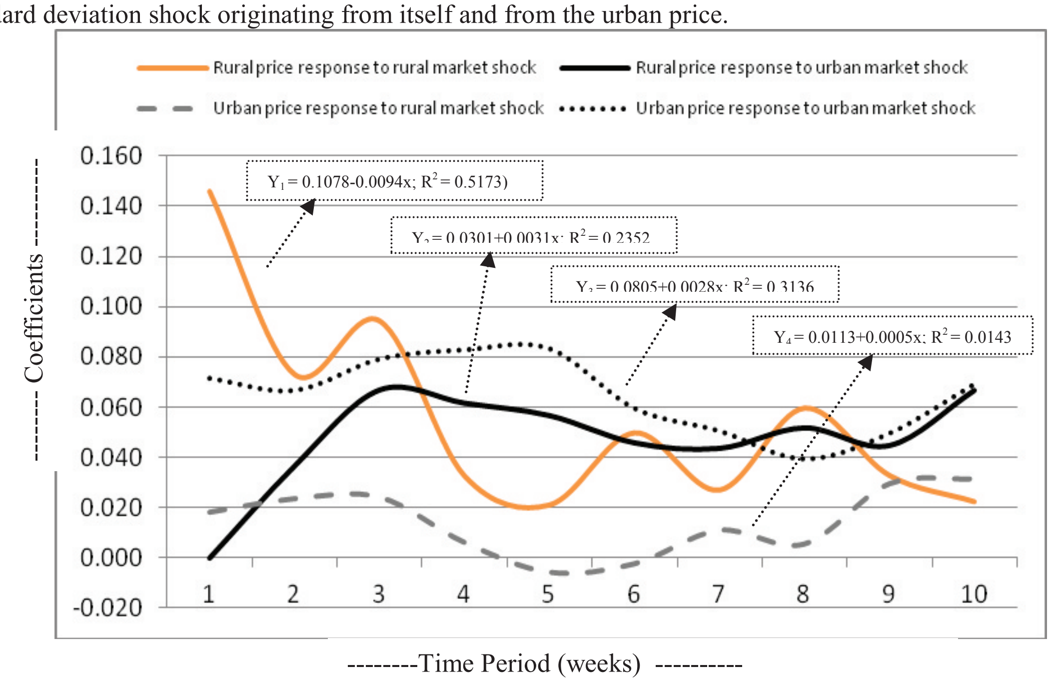


Figure 3: Trends of impulse response of rural and urban prices to a one standard deviation shock

$^{++}$ The response coefficients are based on Cholesky's decomposition; Effect of shock = Coefficient x 100%.

It is evident from the Figure that the response of rural price of roots to shocks emanating from the rural market was initially higher (about 15%) than its response to shocks emanating from the urban markets. It dropped sharply during the second period, rose slightly in the third and continued on a downward trend up to the fifth period. Thereafter, the movement was cyclical but nosedived to as low as 2% during the tenth week. The effect of rural price's shocks on self materialized after one period while it was experienced slightly after the second period for the urban price. The effect of rural prices' shocks on the urban price appeared to be relatively very negligible initially but rose slightly to operate within 3- 6% band from the third to the 10 periods. On its part, the price shock originating from the urban market virtually did not have much impact on the rural price. Rural market shock was mainly responsible for variations in the rural market prices. The impulse responses trends in Figure 3 suggest that the urban market prices adjust to changes in the rural prices in a positive manner.

### 3.7 Forecast error variance decomposition

The impulse responses only provide information on the effect of a standardized price shock, but do not indicate the extent to which a given shock contributes to the level of uncertainty in the price regime. To further assess the relative importance of price shocks, we decompose the forecast error variance into parts that are attributable to shocks emanating from rural and urban markets prices. The proportions of forecast error variances are presented Table 6 for 1 to 10 weeks.

Table 6: Decomposition (%) of 1 to 10 weeks ahead forecast error variance

| Period | Rural market price deviation++ | | Urban market price deviation++ | |
|---|---|---|---|---|
| | RP | UP | RP | UP |
| 1 | 100.0000 | 0.000000 | 6.104714 | 93.89529 |
| 2 | 95.23295 | 4.767050 | 8.534175 | 91.46582 |
| 3 | 86.02710 | 13.97290 | 8.549716 | 91.45028 |
| 4 | 79.31972 | 20.68028 | 6.266314 | 93.73369 |
| 5 | 74.41908 | 25.58092 | 4.968171 | 95.03183 |
| 6 | 72.72926 | 27.27074 | 4.476633 | 95.52337 |
| 7 | 70.66756 | 29.33244 | 4.484049 | 95.51595 |
| 8 | 69.33522 | 30.66478 | 4.382114 | 95.61789 |
| 9 | 67.75218 | 32.24782 | 6.106163 | 93.89384 |
| 10 | 63.77731 | 36.22269 | 7.443716 | 92.55628 |

++ Decompositions are based on Cholesky ordering (standard errors are not reported)

The results show that for changes in the rural market price of fresh roots, the urban prices' shock accounts for a very small percentage of the total forecast error variance. Price shocks from the rural markets account for 63.8% for at the tenth week corroborating the fact that the uncertainty in rural markets was mainly generated by shocks to its own prices. External shocks from the urban market play a relatively limited role in determining variations in the rural markets. Similarly, uncertainty in the urban price was largely determined by shocks to the urban market with the deviation being as high as 92.6% at the tenth week.

## 4. Conclusion and Implication of the Finding

The findings from this investigation point to a lack of clear trend in price leadership between the rural-supply and urban-demand markets' prices of cassava fresh roots. Perhaps, variables other than prices were responsible for adjustments in the market prices. One factor that could explain this is the perishable and susceptible status of fresh roots, which makes them very difficult for farmers to preserve for a fairly long time. The process of deterioration of the fresh roots commences immediately after uprooting and with their 48-72 hours shelf life, it gets worse as days go by. But, it was observed elsewhere that it is still possible to preserve uprooted cassava for up to one week if certain precautions are taken (FAO, 1998). These include ensuring that: (a) stems are carefully cut leaving a short part (about 2-5 cm) above the ground and still attached to the trunk about three weeks before harvesting; (b) roots (attached to the trunk) are uprooted with part of the stem; (c) damage to the roots are minimized at the time of pulling/lifting (to best achieve this, harvesting will be done while the soil is wet, e.g. after a rain); and (d) only roots that do not show signs of injury are carefully selected since curing will not be effective on roots with extensive damage. Other traditional measures identified by FAO (1998) include (e) re-burying the roots in trenches covered with plant material and soil; (f) piling the roots in heaps and keeping them moist by watering them daily; (g) applying a thick coating of soft clay or mud on the stems; and (h) keeping small quantities of cassava in water. At best, each of these may qualify only as a temporary strategy at improving on the shelf life of cassava after harvest. Complementing the problems associated with storage of fresh roots is the fact that an average rural farmer commences farming activities at the commencement of the season (usually with the onset of initial rainfall) partly to boast ego and command respect among his kinsmen. No true farmer wishes to be seen as lazy or a loafer, who is sleeping when others are busy with farm work. Consequently, most farmers set up their cassava fields simultaneously, implying that the fields mature and are ready for harvesting at the same time. This often leads to glut of roots in the market. Glut results to undervaluing of roots, price crash, wastage, and loss of income for the farmer.

Partly to address these problems, the traditional practice amongst subsistence farmers has been to leave the roots in the ground until they are needed for use in a future data, either processing them into more durable form (FAO, 1998) or selling them to marketers or other consumers. This practice means tying up the farmer's investment, part of which could be borrowed funds, which will continue to accumulate interest charges, until that future date when harvesting will be eventually done. This will definitely add to the cost of production and selling price of the roots, result to default in loan repayment, if the farmer has borrowed. Also, the piece of land will be tied down making it unavailable for further farming activities in the subsequent season.

In effect, the market for raw roots was neither predictable nor reliable. There is need to strengthen cassava value chain with greater emphasis on processing and/or direct sale of roots to commercial processors, that will stand as off-takers of roots. With respect to processing, the cassava enterprise development initiatives have led to the development of several food recipes that are directly derived using sole cassava or by combining cassava with other grain crops, like maize and cowpea. The major problem of getting the farmer directly involved with processing is that processing is a parallel livelihood activity, which is very difficult to combine with full-time farming. Apart from being time- and energy-sapping, processing is also capital intensive and distracting to the farmers.

On the off-take model, there has been conscious effort at developing cassava farm clusters and out-growers' schemes around an identified reliable commercial cassava processor, like factories using cassava for production of intermediate products such as starch, glucose syrup, high quality cassava flour (HQCF), ethanol, amino acids, et cetera. Under this arrangement, incentives are provided for farmers' groups to embark on cassava farming as a business enterprise. These may include provision of input-credit, improved varieties and best farm management practices, trainings, extension services, and other forms of technical support, which are aimed at achieving increased yield and farm income. In addition, the highly controversial issue of price is resolved through a direct negotiation between the processor/buyer and the farmer/supplier at the beginning of the season and the agreement supported by a legal instrument, the memorandum of understanding (MoU), to be signed by both parties. If well implemented, the design will lead to a win-win outcome by successfully addressing the pricing debate. The import of these is to minimize the volume of transaction of raw roots in the open market, thereby eliminating the evil consequences of price shocks that have perpetually left the rural Nigerian farmer rolling in abject poverty.

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