

**PRICE TRANSMISSION BETWEEN SUPPLY AND DEMAND MARKETS FOR
CASSAVA-BASED PRODUCTS: A COINTEGRATION ANALYSIS FOR *GARI* IN
ENUGU STATE, NIGERIA**

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ABSTRACT

The theory of demand and supply implied a positive relationship, or price information transmission between the supply and demand markets for products. Using cointegration analysis and weekly data from week 37 in 2004 to week 26 in 2006, a long-run equilibrium relationship was investigated between the prices for the yellow and white varieties of *gari*, a granulated dry food product processed from cassava roots, in a typical rural (supply) and urban (demand) markets in Enugu State of south-eastern Nigeria. The Augmented Dickey-Fuller (ADF) test was used to check for stationarity in the pairs of prices while the Engle and Granger two-step procedure was used to test for cointegration of the markets. Results revealed that, although yellow *gari* sold for relatively higher prices than the white *gari* in both the rural and urban markets, the market prices were significantly positively correlated for the two products. The tests for unit roots revealed that the different price series were individually nonstationary while the pair of prices for each product was integrated of order one. The ADF test statistics were calculated as -1.63 and -1.59 in levels and -9.45 and -8.35 in first differences for yellow *gari*. The statistics were also calculated as -1.69 and -1.56 in levels and -10.57 and -9.10 in first differences for white *gari* in the studied rural and urban markets. The results revealed further that the rural and urban markets were cointegrated with t-statistics calculated as -4.09 for yellow *gari* and -4.20 for white *gari*. Changes in prices in one of the markets reflected similar long-term changes in prices in the other. The error correction model did not, however, reveal any significant causality link between the peripheral and central markets, suggesting that there were no clear trends in price leadership between the markets. On the whole, the study had established that there could be efficiency in the transmission of price information among the operators of the traditional food markets in Nigeria. The implication was that the development of the cassava agro-industrial sector might need to generate its own source of raw materials to guarantee food security in Nigeria.

Keywords: Co-Integration, Cassava, *Gari*, Markets, Prices

INTRODUCTION

Price is an important variable in the food demand and supply chain. Apart from serving as signals of both food availability and food access for producers and consumers, prices provide a snapshot of current and expected supply of a commodity. Among other functions, prices help to express the value of a product, provide information on its level of supply in a market and on the marketing agents' perception of the product's future supply and demand, while at the same time act as either an incentive or disincentive for trade and production [1].

It is expected that if the market for a product is efficient, a change in the product's price in a typical rural source market will be followed by similar change in price in the urban market, which is the destination point of the product. The co-movement among related price series implies that a long-run equilibrium relationship should be anticipated between the prices or that the price series are cointegrated [2].

The main objective of this paper is to determine the linkages between the market prices of *gari*, a granulated dry food product processed from cassava roots, in a typical rural supply market and a typical urban destination and demand market in Nigeria, using cointegration analysis. *Gari* is perhaps the most popular cassava-based food security product, which has gained the status of an urban-convenient food in Nigeria [3]. Although primarily processed in the rural communities, where it provides employment for millions of rural women, the major *gari* consumption markets are found in the urban and semi-urban city centres across Nigeria. In a recent investigation, it was found that *gari* was traded in all the major urban markets and these urban markets are supplied by 90% of the rural markets in the major cassava producing regions of Nigeria [4].

Gari usually comes in two colours, the yellow and white *gari*. Traditionally the two types of *gari* can be produced from the same cassava, but the addition of red (palm) oil to the cassava paste before frying helps to achieve the yellow colour of *gari*. Addition of red oil helps to increase the vitamin A content of *gari*, but can also slightly reduce its storability. Recently, scientific research by cassava scientists in the International Institute of Tropical Agriculture, Nigeria, has led to the release of some pro-vitamin A cassava clones, including Tms 01/1368, Tms 01/1663, and Tms 01/1371, which have carotenoid contents of 7.34, 7.10, and 6.92 micrograms per gram ($\mu\text{g/g}$) respectively. These germplasms belong to the family of the "yellow root cassava" that can be used by farmers to produce yellow *gari* without adding the red oil. One of the advantages of the new technology is that it reduces the cost of production of yellow *gari* for the farmer or processor. Moreover, the *gari* produced from the yellow roots is more durable and contains high-quality vitamin A. At the level of the consumer in the market, it has not been easy to distinguish the yellow *gari* prepared with red oil and that made from the yellow roots. In general, the yellow *gari* commands a relatively higher market price and is also slightly preferred to the white *gari*, especially in the southeast area of Nigeria where this study was conducted.

METHODOLOGY

The study area

Two markets were used for the study: the rural market is the Orié Orba Market (located at latitude 6.856° and longitude 7.459°) in Nsukka senatorial district and the urban market is the Ogbete Main Market (located at latitude 6.43445° and longitude 7.48488°) in Enugu City, both in Enugu State of southeastern Nigeria. Rapid appraisal of markets for cassava-based products showed that traders from Enugu city market purchased 80-90 percent of the yellow and white brands of *gari* produced and sold by farmers in Orié Orba. By implication whereas Orié Orba was a rural source (supply) market, Ogbete Market in Enugu was an urban destination (demand) market for *gari* in the products' supply-demand chain.

Price data

The market information service (MIS) unit of the Integrated Cassava Project (ICP) of IITA documents weekly market prices for over 20 Nigerian agricultural commodities collected from about 50 urban and rural markets in Nigeria. Price data for the products are available on the ICP website <http://www.cassavabiz.org> since 2004. The available prices include those of yellow and white *gari* brands for different rural and urban markets, including Orié Orba and Enugu main markets. For this study, a total of 93 weeks, starting from week 37 of (September) 2004 to week 26 of (June) 2006 were used in the analysis. The trends in the weekly prices in the rural source and urban destination markets are shown in Figure 1 for yellow *gari* and Figure 2 for white *gari*. The two sets of prices had a slightly positive long-run trend.

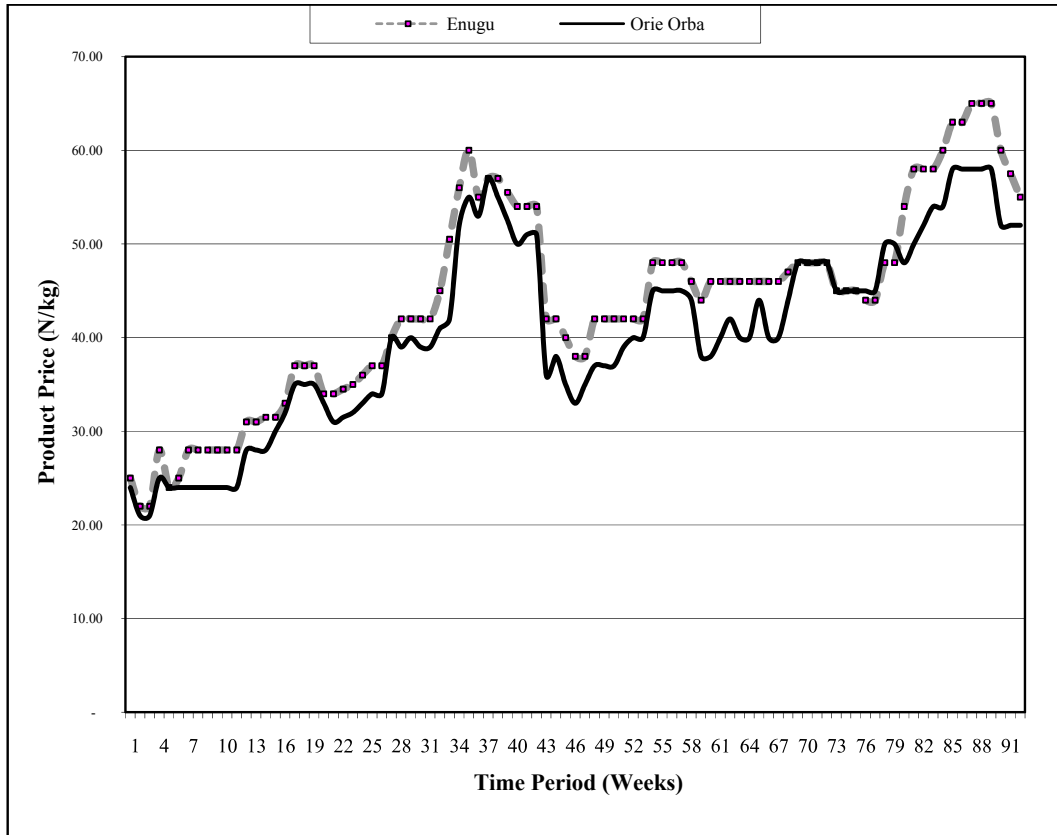


Figure 1: Trends in prices of yellow *gari* in surveyed urban and rural markets

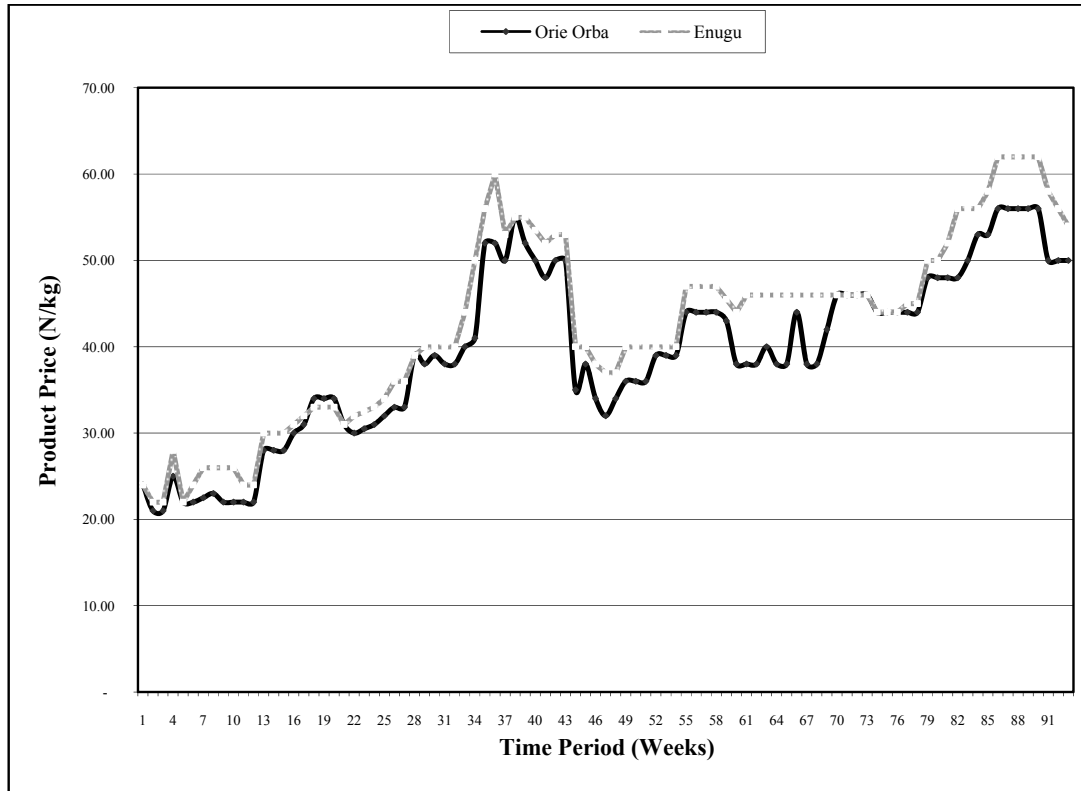


Figure 2: Trends in prices of white gari in surveyed urban and rural markets

Correlation Analysis

Suppose p_{yr} and p_{yu} are the rural supply and urban demand market prices of a product, y , correlation analysis of the prices in the markets, has become the most common approach to measuring co-movement of prices, which underlie the intuitive idea of market integration, owing to its simplicity [5]. The use of the correlation tool relates to the idea that integrated markets display prices that move together [5]. The analysis was based on the Pearson’s product moment correlation coefficient for the rural and urban market prices of gari (r_{ur}) while the test statistic was used to ascertain if the coefficient between prices in the markets was statistically different from zero.

Cointegration tests

The fundamental aim of co-integration analysis is to detect any common stochastic trends in economic data series, and to use these common trends to conduct a dynamic analysis of correlation returns. The term cointegration refers to statistical implication of long-run relationship between economic variables [6]. A long-term relationship implies that the two cointegrated prices move together overtime so that short-term disturbances from the long-run trend can be corrected [7]. Absence of cointegration suggests absence of long-run relationship between the two prices of interest, implying in principle that they can wander arbitrarily far away from each other [8]. A set of non-stationary prices is cointegrated if some

linear combinations of the prices are stationary [2]. The investigation of stationarity or nonstationarity in a time series is closely related to the tests of unit roots since existence of unit roots in a time series denotes non-stationarity [9]. In which case the ordinary least squares (OLS) estimator is not normally distributed.

In the case of the price of yellow *gari* (p_y), suppose we have an (k+1)th order autoregressive time series given as:

$$p_{y(t)} = a_1 p_{y(t-1)} + a_2 p_{y(t-2)} + \dots + a_k p_{y(t-k)} + a_{k+1} p_{y(t-k-1)} + e_t \quad (1)$$

where $p_{y(t)}$ is the price of *gari* in current period, $p_{y(t-i)}$ for $i=1, \dots, k+1$ are prices lagged by one through $k+1$ periods, a_i , $i=1 \dots k+1$ are parameters to be estimated and e_t is the error term. The price series, $p_{y(t)}$, is said to be stationary if all the characteristic roots associated with equation (1) are less than one in absolute value. If, however, a unit root exists, $p_{y(t)}$ is said to be non-stationary. Having a unit root means that the sum of the autoregressive parameters is one, implying that, we can test for a unit root by testing whether the sum of the autoregressive parameters is one.

Figures 1 and 2 suggest that the urban and rural markets' price series for the two brands of *gari* were not stationary. To test for stationarity or otherwise of the products' prices series, we applied the Augmented Dickey-Fuller (ADF) test [10]. This was based on the parameterized model of equation (1) stated with intercepts for as:

$$\Delta p_{yr(t)} = \delta_0 + \delta_1 p_{yr(t-1)} + \phi_1 \Delta p_{yr(t-1)} + \phi_2 \Delta p_{yr(t-2)} + \dots + \phi_k \Delta p_{yr(t-k)} + e_{1t} \quad (2)$$

$$\Delta p_{yu(t)} = \delta_0 + \delta_1 p_{yu(t-1)} + \phi_1 \Delta p_{yu(t-2)} + \phi_2 \Delta p_{yu(t-3)} + \dots + \phi_k \Delta p_{yu(t-k)} + e_{2t} \quad (3)$$

where $p_{yr(t)}$ and $p_{yu(t)}$ are respectively the rural source and urban destination market prices of yellow *gari*, Δ refers to the difference operator, implying that $\Delta p_{yr(t)} = p_{yr(t)} - p_{yr(t-1)}$ and $\Delta p_{yu(t)} = p_{yu(t)} - p_{yu(t-1)}$; $\delta = (a_1 + a_2 + \dots + a_{k+1}) - 1$ and $\phi_k = -a_{k+1} - \dots - a_{p+1}$ are parameters to be estimated and e_{1t} and e_{2t} are the error terms. Similar set of equations was also estimated for white *gari*.

We obtained the estimators by respectively regressing $\Delta p_{yr(t)}$ on $p_{yr(t-1)}$, $\Delta p_{yr(t-1)}$, $\Delta p_{yr(t-2)}$, \dots , $\Delta p_{yr(t-k)}$ or $\Delta p_{yu(t)}$ on $p_{yu(t-1)}$, $\Delta p_{yu(t-1)}$, $\Delta p_{yu(t-2)}$, \dots , $\Delta p_{yu(t-k)}$. The t-statistic of the ordinary least squares estimator of δ_1 is the test statistic for the unit root test. The null hypothesis of non-stationarity, or unit root ($\delta_1=1$), was accepted at the 0.05 levels if the ADF statistics exceeded the critical value of -2.89. The practical rule for establishing the lag length (k) is that number of lags should be relatively small so as to save degrees of

freedom, but large enough not to allow for the existence of autocorrelation in the error term [9]. In this study, we set the order of the autoregression at $k=8$ to avoid over-parameterization of the unit root test and consequently give the test greater statistical power [10].

If non-stationary was established in each of the price series, we would proceed to testing if the series were cointegrated. This was achieved using the residuals (u_t) in the long-run regression models stated below [11, 12]:

$$P_{yr(t)} = \mu_0 + \mu_1 P_{yu(t)} + u_t \quad (4)$$

$$P_{wr(t)} = \mu_0 + \mu_1 P_{wu(t)} + w_t \quad (5)$$

Equation (4) is the long run relationship of the rural and urban prices for yellow *gari* while equation (5) is for white *gari*. $P_{yr(t)}$ and $P_{wr(t)}$ are the prices of yellow and white *gari* in the rural source market, $P_{yu(t)}$ and $P_{wu(t)}$ are the prices in the urban destination market, and u_t and w_t are the error terms. Equations (4) and (5) are called the cointegrating regression. Cointegration was rejected if by replacing $P_{yr(t)}$ and $P_{wr(t)}$ in the autoregressive equations (2) and (3) by the residuals, u_t and w_t from equations (4) and (5) we find that the coefficient of the lagged residual is not significantly different from one [10]. The models are given respectively for yellow and white *gari* as:

$$\Delta \hat{u}_t = \alpha_1 \hat{u}_{t-1} + \sum_{i=1}^k \gamma_i \Delta \hat{u}_{t-i} + \varepsilon_{1t} \quad (6)$$

$$\Delta \hat{w}_t = \alpha_2 \hat{w}_{t-1} + \sum_{i=1}^k \lambda_i \Delta \hat{w}_{t-i} + \varepsilon_{2t} \quad (7)$$

where \hat{u}_t and \hat{w}_t are the retained residuals, α s and γ s are unknown parameters to be estimated and ε_{ts} are error terms. The models are used to test $H_0: \alpha=0$ against $H_1: \alpha < 0$ using appropriate critical values. By implication, the null hypothesis of the cointegration test is that the series formed by the residuals of each cointegrating regressions are not stationary. It was observed that the cointegrating regression had no intercept or time trend since the error term must have zero mean [9].

Vector autoregressive model and causality tests

If it followed from the cointegration tests that the pair of non-stationary price series was not cointegrated, it became justified to build the vector autoregressive (VAR) models in the first price differences to describe the dynamic relationships between the variables and use them for the causality tests [12]. Details and process of deriving the VAR models from the economic theory of demand can be found elsewhere [10]. The VAR models are estimated by

OLS while the test of causality of the urban price on the rural price of *gari* is equivalent to the test of the null hypothesis that the coefficient of the lagged *urban price* in the rural price equation is zero. The simple F-ratio, which compares the restricted and the unrestricted models, is usually used for the causality test. The decision rule is that if the calculated is less than the tabulated *F*, the “urban price Granger causes the rural price of *gari*”, otherwise the “rural price Granger causes the urban price”. If the urban price causes the rural price and the rural price causes the urban price, then a feedback relationship exists between the two prices and causality is in Granger’s sense or in the sense of predictability [10].

The vector error correction model

If, however, cointegration were concluded in relation, then the vector error correction model (VECM) would be estimated. Error correction models are based on the behavioral assumption that two or more time series exhibit an equilibrium relationship that determines both short- and long-run behavior [11]. It has been shown that if p_{yu} and p_{yr} are cointegrated, then there exists the VECM representation of the dynamic system governing their joint behavior overtime [12]. This is because the error correction model tells us the degree to which the long-run equilibrium behavior drives short-run dynamics [11]. The relationship between cointegration and error correction is demonstrated in the Granger Representation theorem, which states that an error correction model representation for a set of variables that are integrated of order one implies cointegration among the variables and vice versa [13]. The estimated models are of the forms:

$$\Delta p_{yr(t)} = \delta_1 + \alpha_y \hat{u}_{yr(t-1)} + \sum_{t=i}^k \psi_{1i} \Delta p_{yr(t-i)} + \sum_{t=1}^k \xi_{1i} \Delta p_{yu(t-i)} + v_{1t} \tag{8}$$

$$\Delta p_{yu(t)} = \delta_2 + \alpha_w \hat{w}_{yu(t-1)} + \sum_{t=i}^k \psi_{2i} \Delta p_{yr(t-i)} + \sum_{t=1}^k \xi_{2i} \Delta p_{yu(t-i)} + v_{2t} \tag{9}$$

where the δ_s , α_s , β_s , ψ_s , and ζ_s are unknown parameters to be estimated, $\Delta p_{yr(t)}$ and $\Delta p_{yu(t)}$ respectively represent the first differences in prices of *gari* in the rural source and urban destination markets, *k* is the lag length, \hat{u}_{yr} and \hat{w}_{yu} are previous period’s equilibrium errors, that is the residuals from the cointegrating regression, and v_t denotes white noise error, with zero mean, constant variance-covariance between v_{1t} and v_{2t} , and zero autocorrelation. Models (8) and (9) are estimated as to maintain the models parsimonious and receive the v_t as white noise. However, of particular interest from the outcome of the VECM are the parameters α_y and α_w , which are the “error correction terms” because they estimate the speed at which the series returns to equilibrium, that is, the correction of the discrepancy between the actual and the long-run changes in *gari* prices.

RESULTS

Descriptive statistics

Two pairs of price series were analyzed: a pair each for yellow and white *gari* in the rural source and urban destination markets. The descriptive information on the price series is presented in Table 1.

The rural average price of yellow *gari* was ₦40.61 per kilogram compared with ₦39.34 per kilogram for white *gari*, reflecting a difference of 3.18%. For the urban market the average price of yellow *gari* was ₦43.85 per kilogram as against ₦42.47 per kilogram for white *gari*, showing a price difference of 3.20%. Between the markets, the average urban price of yellow *gari*, that is, ₦43.85 per kg was higher than the rural average calculated as ₦40.61 per kg by 7.67%. For white *gari* the difference between the average urban and rural market prices, which was ₦3.13 per kg, represents 7.65%.

The correlation coefficients were calculated as 0.98 between the rural and urban market prices of both *gari* products. Both coefficients were significant at less than 0.01 levels. This high correlation, further corroborated by the trends in the price series shown in Figures 1 and 2, suggests the likelihood of existence of long-run relationship between rural and urban price series for each of the *gari* products in the two market prices. This was consequently subjected to further investigation using the cointegration analysis. The first step is to test for stationarity or nonstationarity in the price series or simply to determine if there are unit roots.

Presence of unit roots – ADF-test

The Augmented Dickey-Fuller (ADF) method was used to test for existence or non-existence of unit roots in the data series. The null hypothesis of non-stationarity or presence of unit roots could not be rejected for all price series. As presented in Table 2, the ADF test statistics calculated at levels for the price series of yellow *gari* was -1.63 for the rural market and -1.59 for the urban market.

The values in first differences were -9.45 and -8.35 respectively. In the case of the price series for white *gari* the ADF test statistics calculated at levels were -1.69 for the rural and -1.56 for the urban markets. In their first differences, the statistics were calculated as -10.57 and -9.08 respectively for the two brands of *gari*. When compared with the ADF test critical values given as -2.89 at 5% levels for a model without intercept, the results reveal that all the series were non-stationary and integrated of order one, that is, they were I (1) series. This result is necessary and sufficient for a test of cointegration of the price series.

Presence of co-integration

Applying the Engle and Granger two-step procedure, cointegration between the rural and urban market prices were tested. First, a “long-run relationship” was regressed for the prices in the two markets using OLS. The results based on the relationships in equation (5) for yellow and equation (6) for white *gari* is presented in Table 3.

In the second step, the residuals from the relationships in the regression models were extracted and the ADF test applied on the residuals to test for existence or otherwise of unit root in the resulting series. The ADF critical value for a model with an intercept is also given as -2.89 at 5% significance level. The regression results are presented in Table 4 for yellow and Table 5 for white *gari*.

The ADF test statistics for cointegration between Oris Orba rural and Enugu urban markets prices for yellow *gari* at levels was calculated as -4.09. In the case of white *gari* the ADF test

statistics for cointegration at level was -4.20 for the rural and urban markets. Tests at first differences reveal higher t-values for both sets of prices. It shows that for both products, the 5% critical values were lower (in absolute terms) than the calculated t-values. We reject the null hypothesis of nonstationarity and conclude that there is long-run relationship between the rural and urban market prices for the two types of *gari* products. The results mean that there is evidence of significant cointegration between the prices of the two grades of *gari* products.

The vector error correction model

If cointegration had not been concluded in the series, Granger's causality test would have been modeled to build the vector autoregressive (VAR) models in the first price differences and consequently describe the dynamic relationships between the variables and use them for the causality tests. However, since cointegration link was concluded we proceed to constructing the error correction model to estimate the short-run deviations of the prices series from the long-run equilibrium based on equations (8) and (9). To control for the objective of making the residual (v_t) a white noise, the residuals were checked for serial correlation. The results obtained from fitting the model are presented in Table 6 for the two products. The lag length was set at $k = 2$.

None of the parameters α_y and α_w associated with the lagged residual ($\hat{\epsilon}_{t-1}$) was found significant in any of the two models.

DISCUSSION

Table 1, which presents results of the descriptive analysis, shows that the rural average price of yellow *gari* was higher than the rural average for white *gari*. It reflects a difference of 3.18% implying that on the average yellow *gari* tends to be relatively more expensive in both the rural and urban markets. Between the rural source and urban destination markets, the averages of 7.67% and 7.65% observed for the two *gari* product types could reflect the marketing agents' margins. It has been succinctly argued that considering the high cost of transactions and the risk to invested capital that these agents' margins are often reasonable [1].

The high and significant correlation of the price series calculated as 0.98 and reflected in Figures 1 and 2 is an indication of co-movement in the prices. The ADF tests presented in Table 2 led to the conclusions that each of the series was non-stationary and integrated of order one, $I(1)$. Also, cointegration was concluded leading to the construction of the ECM to estimate the short-run deviations of the prices series from the long-run equilibrium. Results show that the error correction coefficients exhibit insignificant biases in the estimators. By implication, the estimated rate of price reequilibration was not significantly affected by departures from the unit roots or degree of simultaneity. The results suggest that although cointegration existed between the price series, no significant causality link could be established from either the rural to the urban market or vice versa. This implies that price information flow could originate from any of the markets since the markets cannot be segmented. Internally and externally determined factors may cause price changes in either the rural or the urban market but because the markets are cointegrated, efficiency can be achieved in transmission of price information in the two markets.

CONCLUSION

This study investigated the long-run relationships in the prices of two popular cassava-based food security products, yellow and white *gari*, in typical urban demand and rural supply markets in Nigeria. Results revealed that the rural and urban market price series for both product types were positively and significantly correlated. Both cassava products were also non-stationary and cointegrated implying that changes in prices in one of the markets reflect similar changes in the other. These finding suggests that efficiency could be achieved in the transmission of price information among the operators in the two markets for cassava-based products especially for white and yellow *gari*. Although significant directional causality link could not be established in price information flow between the two markets, the presence of cointegration is an indicative of interdependence in the price series and the markets cannot be segmented. It goes to say that the development of the cassava agro-industrial sector may need to generate its own source of raw materials to guarantee food security.

Table 1: Descriptive statistics of *gari* product prices⁺ for urban and rural markets

Statistic	Yellow <i>gari</i> (n=93)		White <i>gari</i> (n=93)	
	Rural	Urban	Rural	Urban
	(p_{yr})	(p_{yu})	(p_{wr})	(p_{wu})
Mean	₦40.61/kg	₦43.85/kg	₦39.34/kg	₦42.47/kg
Standard Deviation	10.15	10.72	9.84	10.83

⁺The average exchange rate of the Nigerian Naira (₦) to the US Dollars was about ₦120/US\$1.00 between September 2004 and June 2006 covered by this study.

Table 2: Tests of unit roots in weekly *gari* prices in source and destination markets

Variable	Market	ADF ^a statistic			
		Tests at levels		Test at first differences	
		Int. only	Int. & trend	Int. only	Int. & trend
P_{yr} (Rural price of yellow <i>gari</i>)	Orie Orba	-1.630	-2.312	-9.454	-9.429
P_{yu} (Urban price of yellow <i>gari</i>)	Enugu Main	-1.591	-2.358	-8.345	-8.348
P_{wr} (Rural price of white <i>gari</i>)	Orie Orba	-1.691	-2.498	-10.572	-10.539
P_{wu} (Urban price of white <i>gari</i>)	Enugu Main	-1.562	-2.067	-9.095	-9.081
ADF Test Critical values at 5%		-2.893	-3.459	-2.894	-3.460
ADF Test Critical values at 1%		-3.503	-4.061	-3.504	-4.062

Int.= Intercept

^aAugmented Dickey-Fuller (ADF) test for a model with an intercept, based on regression: $\Delta y_t = a_0 + a_1 y_{t-1} + b_1 \Delta y_{t-1} + b_2 \Delta y_{t-2} + \dots + b_n \Delta y_{t-n} + \varepsilon_t$, where y_t is the market price under reference. The null hypothesis of unit root ($H_0: a_1 = 1$) cannot be rejected if the ADF statistic is greater than the critical value given as -2.89 for the 95% confidence levels. The maximum lag of 8 was used for all tests.

Table 3: Estimation of long-run relationships between rural and urban *gari* prices

Equation	Variable		Coefficient	Std. Error	R ²	F-value	P-value	D-W
	Dependent	Explanatory						
(7)	$p_{yr(t)}$	Constant	0.078	0.961	0.954	1884.37	<0.001	0.732
		$p_{yu(t)}$	0.924***	0.024				
(8)	$p_{wr(t)}$	Δu_{t-2}	1.712*	0.926	0.951	1757.76	<0.0001	0.839
		$p_{yu(t)}$	0.886***	0.021				

p_{yr} =Rural price of yellow *gari*; p_{yu} =Urban price of yellow *gari*; p_{wr} =Rural price of white *gari*; p_{wu} =Urban price of white *gari*.

***=Significant at 1%, **=significant at 5%, *=significant at 10%

Table 4: Testing for unit roots in regression residuals for yellow *gari* model

Equation	Variable		Coefficient	Std. Error	R ²	F-value	P-value	D-W
	Dependent	Explanatory						
(9)	Δu_t	Constant	0.049	0.185	0.296	3.46	0.001	1.997
		u_{t-1}	-0.564***	0.138				
		Δu_{t-1}	0.214	0.151				
		Δu_{t-2}	0.033	0.153				
		Δu_{t-3}	0.230	0.139				
		Δu_{t-4}	0.093	0.138				
		Δu_{t-5}	0.185	0.130				
		Δu_{t-6}	-0.022	0.127				
		Δu_{t-7}	0.316***	0.116				
Δu_{t-8}	0.013	0.117						

***=Significant at 1%, **=significant at 5%, *=significant at 10%

Dependent variable is Δu_i for $i=1,2...8$; ADF Critical value at 5%=-2.89

Table 5: Testing for unit roots in regression residuals for white *gari* model

Equation	Variable		Coefficient	Std. Error	R ²	F-value	p-value	D-W
	Dependent	Explanatory						
(10)	Δw_t	Constant	0.076	0.195	0.331	4.07	0.0003	2.002
		w_{t-1}	-0.646***	0.154				
		Δw_{t-1}	0.183	0.157				
		Δw_{t-2}	0.132	0.154				
		Δw_{t-3}	0.351**	0.141				
		Δw_{t-4}	0.210	0.142				
		Δw_{t-5}	0.301**	0.134				
		Δw_{t-6}	0.090	0.135				
		Δw_{t-7}	0.291**	0.123				
		Δw_{t-8}	0.074	0.116				

***=Significant at 1%, **=significant at 5%, *=significant at 10%

Dependent variable is Δw_i for $i=1,2 \dots 8$; ADF Critical value at 5%=-2.89

Table 6: Estimated results of the error-correction model for yellow and white *gari*

Equation	Dependent Variable	Yellow <i>gari</i>			White <i>gari</i>		
		Exp. Var.	Coefficient	Std. Error	Exp. Var.	Coefficient	Std. Error
(11)	$\Delta P_{yr(t)}$	Constant	0.251	0.304	Constant	0.26557	0.31109
		\hat{e}_{t-1}	-0.236 ^{NS}	0.165	\hat{e}_{t-1}	-0.269 ^{NS}	0.170
		$\Delta p_{yr(t-1)}$	-0.080	0.188	$\Delta p_{wr(t-1)}$	-0.141	0.189
		$\Delta p_{yr(t-2)}$	-0.189	0.179	$\Delta p_{wr(t-2)}$	-0.286	0.173
		$\Delta p_{yu(t-1)}$	0.162	0.203	$\Delta p_{wu(t-1)}$	0.097	0.203
		$\Delta p_{yu(t-2)}$	0.281	0.200	$\Delta p_{wu(t-2)}$	0.382 ^{**}	0.189
			[R ² =0.09; F-value=1.66; p=0.15; DW=1.96]	[R ² =0.13; F=2.49; p=0.04; DW=1.97]			
(12)	$\Delta P_{yu(t)}$	Constant	0.299	0.276	Constant	0.320	0.289
		\hat{w}_{t-1}	-0.177 ^{NS}	0.141	\hat{w}_{t-1}	-0.142 ^{NS}	0.143
		$\Delta p_{yr(t-1)}$	-0.135	0.169	$\Delta p_{wr(t-1)}$	-0.072	0.175
		$\Delta p_{yr(t-2)}$	-0.125	0.162	$\Delta p_{wr(t-2)}$	-0.252	0.160
		$\Delta p_{yu(t-1)}$	0.242	0.184	$\Delta p_{wu(t-1)}$	0.114	0.189
		$\Delta p_{yu(t-2)}$	0.168	0.182	$\Delta p_{wu(t-2)}$	0.245	0.177
			[R ² =0.04; F-value=0.64; p=0.67; DW=1.93]	[R ² =0.04; F=0.61; p=0.69; DW=1.93]			

Exp. Var.=Explanatory variable;

^{***}=Significant at 1%, ^{**}=significant at 5%, ^{*}=significant at 10%; NS=Not significant

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