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SPATIAL INTEGRATION OF MAIZE MARKET IN NIGERIA – A VECTOR ERROR CORRECTION MODEL

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Abstract

Agricultural commodities are produced over an extensive spatial area and are costly to transport relative to their total value as this inhibits efficient functioning of the markets. The study examined spatial market integration among geographically separated maize markets in Nigeria using monthly retail price data of maize grain from January 2001 – December 2010 in the selected producing and consuming states. The data were analyzed using Johansen co-integration and Vector error correction model (VECM). In the long run, the states were co-integrated and the rate at which VECM restored deviation from equilibrium was moderate. The study showed that spatial price linkages exist within maize market as products moved efficiently across market which is related to efficiency of price information flow. The study recommends that farmers should be provided with more price information in order to take advantage of spatial price differences.

Keywords: *Co-integration, maize market, Nigeria, spatial integration, vector error correction.*

1. Introduction

Attainment of an efficient market performance is determined by the extent to which price signals are transmitted across markets. In Nigeria over the years, self sufficiency in food production, effective marketing system and pricing policies which will ensure stable and remunerative incomes for farmers has been the nation's target. However, there are several impediments to the efficient functioning of markets, particularly agricultural commodity markets. These include high cost of transportation, difficulties in access to market information, lack of viable and cheap post harvest technology that results in post farm gate losses due to perishable nature of agricultural products. Onyuma (2006) observed that despite the nation's dependence on agriculture for food security, majority of agricultural markets in Nigeria and other Africa countries are inefficient and poorly integrated. Coupled with the above is the high and rising food price which is a concern to the general public and policy makers because such price movements are deterrent to increased agricultural productivity and tend to intensify inflationary pressures. Most agricultural commodity markets prices are characterized by a high degree of volatility because agricultural output varies from period to period because its nature dependent. Prices of agricultural commodities are usually low during harvest time (boom) and prices are high if demand exceeds supply which could be as a result of natural shocks such as weather and pests. In order to get supply and demand back into balance after a supply shock, prices therefore have to vary rather strongly.

Agricultural commodities are typically produced over an extensive spatial area and are costly to transport relative to their total value. Fackler and Goodwin (2002) noted that these characteristics of agricultural products yield a complex set of spatial price linkages which needed to be studied to gain insights into the performance of markets. In addition, Okoh (2005) reported that the marketing system of Nigeria's food failed to address price stability from time to time due to information asymmetry. Understanding the extent to which prices are transmitted across market is imperative to examine how producers and consumers in maize markets are likely to respond to price changes. The attainment of inter-regional equity is of vital importance if Nigeria is to realize its marketing and pricing policy objectives. There is the possibility that a price change in one market would result in a series of price responses that spread throughout contiguous market areas (rural markets). But, such price changes may not have much effect on more distant markets, making the attainment of an integrated marketing system a mirage.

Maize is one of the most important cereal crops in Nigeria. It is a major staple consumed by households in Nigeria. Maize produced in Nigeria was 7.6 million tons in 2012/2013 of which 1.7 million tons were used for feed production (USDA Foreign Agricultural Science, 2013). Nigeria is the 10th largest producer of maize in the world and major producer in tropical Africa with an annual production in excess of 6 million metric tons (USAID/MARKETS, 2010).There is a rising demand in prices of maize grain owing to its use as an important raw material in the animal feed, food and beverage industries. To this end, there is need to examine the maize market integration with other markets. The main objective of the study is to examine the extent to which price signals are transmitted spatially and the rate at which price deviation is restored in the short run across maize markets in Nigeria.

An evaluation of maize price behaviour and dynamics in this study would reveal the market's ability to efficiently allocate maize crop among various users. This is particularly important for the dichotomized Nigerian economy with its increasing population of urban food deficit centres and food surplus rural areas. There is a need to develop the capacity of the market system to efficiently distribute and transfer the increased (excess over farmers consumption) maize supply from food surplus rural areas to food deficit urban centres as this boost food security and increase export gain. This would involve unimpeded food price information flow between producing states and consuming states.

Spatial market integration refers to co-movements or the long-run relationship among prices. In Goletti, Ahmed, & Fraid (1995), defined spatial market integration as the smooth transmission of price signals and information across spatially separated markets. However, Goodwin & Schroeder (1991) observed that if price changes in one market are fully reflected in an alternative market then these markets are said to be spatially integrated which indicate overall market performance. Therefore, price transmission among markets is central to understanding the extent of the integration in the market process. In order to facilitate agricultural development process, analysis of market integration is considered pertinent and it is expected that favourable pricing efficiency will stimulate production and marketing.

2. Theoretical Framework

Several techniques have been used to test the degree of integration in spatially separated markets. Earlier works on market integration used correlation analysis to determine prices movements in spatially separated markets but been limited by population growth and climatic patterns (Wyeth, 1992). Regression-based procedures have also been used to test for spatial price integration (Alexander & Wyeth, 1994). However, the use of regression-based tests has several shortcomings. The models are intrinsically static in nature because adjustment lags are not explicitly recognized and contemporaneous arbitrage conditions are assumed to hold. Also, non stationarity of price data may invalidate standard econometric tests thus giving misleading results regarding the degree to which price signals are being transmitted from one to another market. The limitations related to the neglect of transaction costs and price variation within the transaction cost band also apply to regression tests.

Measuring the degree at which prices are transmitted lacks a single explicit empirical test as identified by Kilima (2006) because of market dynamic relationship that arise due to discontinuity and non linearities that arise due to distortion in arbitrage. However, in this study co-integration and vector error correction was used for the study while Augmented Dickey-Fuller (ADF) test was used to test for stationarity of variables. The test statistic from the testing regression is known as the statistic critical values (Dickey & Fuller, 1979). The regressions provide a t-statistic of the estimated δ. The t-statistic is then compared to the critical value t-statistic, If the value of the ADF statistic is less that is more negative, (because these values are always negative) than the critical value at the conventional significant level (usually the five percent significant level) then the series (Y_t) is said to be stationary and vice versa.

$$\Delta Yt = \beta 1 + \beta 2t + \delta\, Yt - 1 + \sum_{i=1}^{k} \rho i\, \Delta\, Yt - i + Et \qquad (1)$$

$\Delta Y_{t-i} = (Y_{t-i} - Y_{t-i-1})$, $\Delta Y = Y_t - Y_{t-1}$, Y_t = price at time t, $\beta 1$, $\beta 2$, δ and ρ are the parameters to be estimated, and E_t is the error term.

Co-integration analysis is concerned with the existence of a stable relationship among prices in different localities. When a long-run linear relation exists among different series, these series are said to be co-integrated (Engle & Granger, 1987). Co-integration, on the other hand, allows a way of dealing with time series data that avoids spurious results, thus enhancing the authenticity of research findings. Johansen (1988) and Johansen and Juselius (1990), developed a multivariate co-integration method which was a robust procedure for testing long run relationship between stationary prices variables and also allow tests for multiple co-integrating vectors. It constructs a test statistic, called the likelihood ratio (LR) test, to determine the number of co-integrating vectors in a co-integration regression. They are trace test and maximum eigenvalue test. The former test the H_o of r co-integrating vectors, where r = 0, 1, 2….n-1, it is computed as

$$LRtr({}^{r}/_{n}) = -T \sum_{i=r+1}^{n} log(1 - \lambda) \qquad (2)$$

The latter tests the null hypothesis of co-integrating vectors against the alternative of r+I cointegrating vectors for r = 0, 1, 2….n-1. This test statistic is computed as:

$$LRmax({}^{r}/_{n} + 1) = -Tlog(1 - \lambda) \qquad (3)$$

n-number of variables in the system, λ – max eigenvalue, T – sample size

Johansen's approach to co-integration is now widely used to test the level of integration among markets as it treats all the variables as explicitly endogenous and takes care of the endogenity problem by providing an estimation procedure that does not require arbitrary choice of a variable for normalization.

Price series of agricultural commodities are often non-stationary (Meyer, 2003). Therefore estimating price adjustment as the impact of a change in one price on another price is based on appropriate methods which allow for non-stationary variables. A vector error correction model (VECM) is applied to evaluate the short run properties of the cointegrated series and also in quantifying the price adjustment across maize markets. Vector Error Correction Model (VECM), a restrictive vector autoregression (VAR) is often used prior to some information concerning the number of co-integrating vectors which is done by sequential likelihood ratio tests for rank determination as shown in Johansen (1988). According to Hendy and Juselius (2000), the use of the VECM is facilitated when variables are stationary at first difference and co-integrated. Therefore, Vector Error Correction Model measure how price deviations restore to equilibrium, as shocks in one market may not be instantaneously transmitted to other markets or due to delays in transportation. Obayelu and Salau (2010) reported that VECM treats all variables as endogenous; restrict long run behaviour to converge to their co-integrating relationships while permitting short run adjustment dynamics. For a bivariate VAR, where X and Y are I(1) and co-integrated

$$\Delta X_t = C_1 + \lambda_1 Z_{t-1} + \beta_1 \Delta X_{t-1} + ---- + a_1 Y_{t-1} + ------ + \varepsilon_{xt} \qquad (4)$$

$$\Delta Y_t = C_2 + \lambda_2 Z_{t-1} + \gamma_1 \Delta X_{t-1} + ------- + \delta_1 Y_{t-1} + ------- + \varepsilon_{xt} \qquad (5)$$

where $(\varepsilon_{xt}\varepsilon_{xt})$ is a bivarate white noise

The literature suggests several approaches to testing spatially market integration using market prices to examine price movement across spatially separated markets. Golletti and Babu (1994), studied market integration of maize in Malawi as affected by market liberalization using measure of integration methods and it was concluded that liberalization has increased market integration over time. Abdulai (2000), tested for spatial price transmission and asymmetry in the Ghanaian maize market, using developed threshold co-integration test. The result showed that major Ghanaian maize markets are well integrated as local markets respond swiftly to major markets. Moshood and Momoh (2007), examined market integration of main staple agricultural commodities in Oyo state Nigeria of which maize was included. Using index of market connectedness (IMC), the result showed that there was high short run market integration between reference and rural maize markets.

Mukhtar and Muhammed (2007) investigated spatial integration in maize markets in Pakistan using co-integration and error correction model. From the result, regional maize markets have strong prices linkages and thus spatially integrated .This suggest that maize market across Pakistan are efficient and functioning well. Thomas *et al* (2010) assessed the degree of market integration and speed of price adjustment of spatial price differentials between SAFEX maize prices in South Africa and maize grain and maize meal prices in Maputo, Mozambique. The findings showed that there is no evidence of long run relationship between Mozambican and South Africa maize grain prices but significant relationship between South Africa maize price and maize meal prices in Maputo because majority of import maize grain from South Africa are milled in Maputo.

3. Materials and Method

3.1 Scope of the study

The study used monthly price data of maize (₦ / kg) sourced from National Bureau of Statistics (NBS) spanning (2001-2010). Eviews econometric software package was used to analyze the data.

3.2 Stationarity Test

Time series stationarity is the statistical characteristics of a series such as its means and variance over time. If both are constant over time, then the series is said to be stationary i.e. there is no random work or unit root, otherwise the series has unit root.

$$Yt = \beta Yt - 1 + Et \quad (6)$$

where Yt is price of maize/state at time t, Et is the error term.

$$Yt - Yt - 1 = \beta Yt - 1 - Yt - 1 + Et \quad (7)$$
$$\Delta Yt = \beta - 1(Yt - 1) + Et \quad (8)$$

$\alpha = \beta - 1$, Δ= first difference operator

In the equation above, Yt is regressed on its one period lagged value $Yt - 1$ to know if β statistically equals 1.if α = 0 then β = 1, the model is said to be characterised by unit root, the equation becomes the random walk model and the series is non –stationary.

For a series to be stationary β must be less than unity in absolute value. Hence stationarity requires that -1< β < 1. (Vavra & Goodwin, 2005). A series without differencing is integrated of order zero; denoted as I(0) while a series stationary at first difference is integrated of order one, denoted as I(1).

3.3 Johansen co-integration test

The Johansen trace test detects the number of cointegrating vectors that exist between two or more cointegrated series. It is computed as

$$LRtr(^{r}/_{n}) = -T \sum_{i=r+1}^{n} log(1 - \lambda) \quad (9)$$

T- total number of variables , where r = 0, 1, 2….n-1

The likelihood ratio (LR) test determines r, the number of co-integrating vector in the equation. The criterion for selection is that the trace statistical value must be greater than the critical value at 5% level of significant, the H_o of no co-integration i.e., r = 0 is rejected.

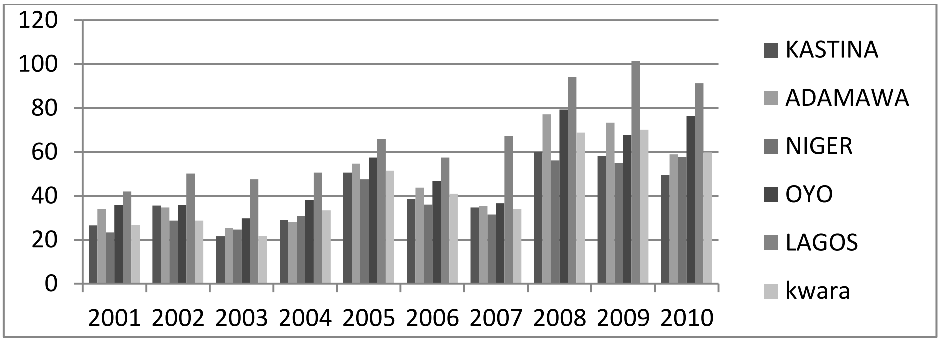
3.4 Vector Error Correction Model (VECM).

Vector Error Correction Model (VECM) examines the dynamic adjustment of variables both in the long and short run to their equilibrium state. Short term dynamics which is a measure of deviation from steady state is determined by Error correction model. If the series are co-integrated it means there is a long-term equilibrium relationship between them so VECM is applied in order to evaluate the short run of the co-integrated series. A negative and significant coefficient of the ECM (i.e. t-l) indicates that any short term fluctuation between variables will give rise to a stable long run relationship between the variables.

4. Results and Discussion

4.1 Descriptive Analysis

Price trend helps to predict the future movement of a stock based on past data. It is based on the idea that what happened in the past years gives traders an idea of what will happen in the future. Figure 1 showed the visual plot of the yearly average of retail prices of maize grain from 2001- 2010 across all states considered. The prices were characterised by fluctuations with a rise in price of maize in 2008which was as a result of food crisis. The prices were volatile especially in Lagos which had the highest prices because of industries using maize grain as raw materials coupled with domestic demand which exceeded supply.



Source: Authors computation from NBS (2010)

Figure 1.The Trend of Maize Price in Nigeria

4.2 Unit Root Test

The unit root test results are presented in Table 1 using Augmented Dickey Fuller (ADF). The test was applied to each variable over the period of 2001 – 2010. Variables are non-stationary at levels and any attempts to use them will lead to spurious regression as suggested by Mesike, Okoh and Inoni (2010). In addition, Yusuf and Falusi (1999) observed that it is not ideal for policy making and cannot be used for prediction in the long run. The variables were all stationary at their first difference at 1% level of significance and integrated of same order i.e. I (1) level. The Ho of unit root for all the time series were rejected at their first difference, since their ADF result test statistic was greater than the critical values at 1% level of significance.

Table1. Result of Unit Root Test for Maize Prices

Price of Maize/State	ADF statistics	Order of Integration
Kastina	-1.9513	Non stationary at level I (0)
	-5.4569	Stationary at first difference I (1)
Adamawa	-1.7747	Non stationary at level I (0)
	-5.3543	Stationary at first difference I (1)
Niger	-1.0304	Non stationary at level I (0)
	-6.1750	Stationary at first difference I (1)
Oyo	-1.1494	Non stationary at level I (0)
	-5.9251	Stationary at first difference I (1)
Lagos	-1.4375	Non stationary at level I (0)
	-6.5011	Stationary at first difference I (1)
Kwara	-1.9399	Non stationary at level I (0)
	-5.3349	Stationary at first difference I (1)

MacKinnon critical values for rejection of hypothesis of a unit root are -3.4885, -2.8868 and -2.5801 at 1%, 5% and 10% respectively.

4.3 Johansen Co-integration Test

Johansen co-integration test addresses existence of long run relationship among the variables. The results based on trace test likelihood ratio are presented in table 2. From the result, the likelihood ratio indicated two co-integrating equations at 5% level of significance as the null hypothesis r = 0 is rejected. From the result, there exist unique long run equilibrium between the producing and consuming states which is in line with Hallam and Zanoli (1992) that where only one co-integrating equation exist, its parameters can be interpreted as estimate of long run co-integrating relationship between variables concerned. Also Kargbo (2005) stated that the higher the number of co-integrating vectors, the stronger the relationship between the variables in the system. It implies that in this study, market efficiency is enhanced as consuming states respond to price signals from producing states leading to increased returns.

Table 2. The Result of Johansen Co-Integration Trace Test

Null hypothesis	Alternative hypothesis	Trace statistic	1% Critical value	5% Critical value	Hypothesized No of Cointegrating Equation(s)
r = 0	r = 1	1.255.014	103.18	94.15	None**
r ≤ 1	r = 2	7.720.818	76.07	68.52	At most 1**
r ≤ 2	r = 3	4.368.648	54.46	47.21	At most 2
r ≤ 3	r = 4	2.235.688	35.65	29.68	At most 3
r ≤ 4	r = 5	1.030.022	20.03	15.05	At most 4
r ≤ 5	r = 6	3.090.711	6.65	3.76	At most 5

Source: Data analysis
** (*) denotes rejection of the hypothesis at 5% (1%) significance level. L. R. test indicates 2 co-integration equations at 5% level of significance.

4.4 Vector Error Correction Model

Existence of co-integration among prices of maize in the states gave rise to estimation of Vector Error Correction Model. Table 3and 4 showed the result of both the long and short run estimates. From the result, the model could not fit the observed data fairly well as indicated by the adjusted R^2 (0.1691). The reason may be as a result of various abnormalities experienced within the spatially integrated markets. It may also imply that the prices of maize alone in states considered was not enough to indicate spatial integration as other exogenous variables such as transactional costs, weather which also influence how spatially a market is integrated were omitted.

Table 3. The Result of Vector Error Correction Model Showing the Long Run Effects

Variables	Coefficient	Standard error	t-value
LG Kas (-1)	1.0000		
LG Ada (-1)	-0.4806	(0.1242)	(-3.8690)
LG Nig(-1)	-0.1666	(0.1338)	(-1.2453)
LG Oyo (-1)	0.5551	(0.1728)	(3.2123)
LG Lag (-1)	0.2885	(0.0905)	(3.1827)
LG Kwa (-1)	-0.8841	(0.1819)	(-4.8617)
Constant	-0.5669		

Source : Data analysis

Table 4. The Result of Vector Error Correction Model Showing the Short Run Effects

Error correction	D(LGKAS)	D(LGADA)	D(LGNIG)	D(LGOYO)	D(LGLAG)	D(LGKWA)
Coint. EQ.1[ECM(-1)]	-0.3480 (0.1168)	-0.1136 (0.1333)	-0.0233 (0.1451)	-0.3793 (0.1223)	-0.2722 (0.0898)	-0.2464 (0.1344)
D(LG KAS (-1))	-0.0916 (0.1335)	0.3338 (0.1523)	0.0635 (0.1658)	0.4217 (0.1397)	0.3099 (0.1026)	-0.1280 (0.15356)
D(LGADA(-1))	-0.1212 (0.1010)	-0.6759 (0.1153)	0.0167 (0.1255)	0.0072 (0.1058)	-0.0939 (0.0777)	0.1821 (0.1162)
D(LG NIG(-1))	0.0844 (0.0994)	0.0299 (0.1135)	-0.2997 (0.1235)	-0.0940 (0.10416)	-0.2273 (0.0764)	-0.0369 (0.1144)
D(LG OYO(-1))	0.1603 (0.1061)	0.0282 (0.1211)	0.0171 (0.1318)	-0.2717 (0.1111)	0.1948 (0.0816)	-0.0069 (0.1220)
D(LG LAG(-1))	0.0016 (0.1242)	-0.1824 (0.1417)	-0.0907 (0.1543)	-0.2985 (0.1300)	-0.3438 (0.0955)	-0.0218 (0.1429)
D(LGKWA(-1))	0.0151 (0.1170)	0.1513 (0.1335)	0.2576 (0.1473)	-0.0731 (0.1225)	0.0116 (0.0899)	0.0092 (0.1346)
Constant	0.0025 (0.0061)	0.00161 (0.0070)	0.0033 (0.0076)	0.0047 (0.0065)	0.0042 (0.0048)	0.0021 (0.0071)

Source: Data analysis
Note: Standard error in parenthesis

R^{-} Squared	0.2622	Adjusted R- squared	0.1611	Log likelihood	159.1684
Akaike info criteria	-2.481511	Schwarz sc	-2.150994		
Mean dependent	0.003498	S.E. equation	0.066163		
F - Statistics	2.816407	Sum square residue	0.450891		

The error correction coefficient for maize prices was (-0.3480), it measures the speed of adjustment of maize prices towards long run equilibrium. It carries the expected negative sign, significant at 5% level and less than one which is appropriate. The coefficient indicates a feed back of about 34.8% of the previous month's disequilibrium from the long run elasticity i.e deviation of maize prices from producing states and consuming state would restored at the rate of 35% i.e within a month among the producing and consuming states. From the analysis, it is deduced that closer markets are more co-integrated than those that are spatially separated and rate at which disequilibrium is corrected (VECM value) is low with distant markets. It is evident that error correction value for Oyo State was 37%, the reason being that it is a national market in Nigeria and there exist spatial price linkages with the producing states.

5 Conclusion and Recommendations

Spatial market integration of maize in Nigeria was approached through co-integration and Vector Error Correction Model. The co-integration test showed there is a long run relationship among the producing and consuming states considered. From the value of the vector error correction model, 35% indicates that any short term disequilibrium among maize prices in the states considered will result to a stable long run relationship. It was evident that price movement within maize market in Nigeria is efficient. It shows there will be efficient distribution of products according to comparative advantage which is a major source of economic growth. In addition, government can formulate policies of providing infrastructure and information regulatory services to avoid market exploitation, as this will facilitate agricultural development process through price stabilization and production decisions that will boost profit. The study recommends that farmers should be provided with more price information in order to take advantage of spatial price differences. Also rural infrastructure that enhances competition among traders should be provided as this minimizes post harvest losses and advantages of spatial price linkages can be achieved.

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