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Market Integration and Price Transmission among Rural and Urban Markets of Selected Cereals in North-Eastern Nigeria

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Abstract

The broad objective of the study was to analyze the behaviour of cereals in North-eastern Nigeria, while the specifically, the study focused on: determined the existence and level of inter-market price dependency, examined the speed of price adjustment to long-run equilibrium and examined the Granger Causality among rural and urban cereal grain markets. The study was conducted in North-eastern Nigeria. Random sampling technique was used to select three states, of Adamawa, Gombe and Taraba, from the six states that made up the North-east geopolitical zone. Only secondary data were used in the study. Secondary data on monthly bases for the prices of 100kg of three cereal grains, maize, rice and sorghum in both rural and urban markets were obtained from Adamawa, Gombe and Taraba States Agricultural Development Programme offices on monthly bases for a period of 10 years (2001-2010). Data were analyzed using inferential statistics such as Vector Autoregressive and Error Correction Models. The results revealed that, the Augmented Dickey-Fuller unit roots test indicated $I(0)$, $I(1)$ and $I(1)$ for maize, rice and sorghum, respectively. Trace statistics for rural and urban markets were not significant ($p > 0.05$). Rural and urban prices of maize responded to shocks within and between each market. The speed with which the system adjusted to shocks and restored equilibrium between the short and the long-run were -0.170725 and -0.29517 for urban and 0.592237 and 0.38034 for rural prices of rice and sorghum, respectively. Granger Causality showed that a bi-directional flow of price signals existed between rural and urban prices of maize.

Keywords: *Price, Efficiency, Cointegration, Unit root, Granger causality, Arbitrage*

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Background to the Study

Spatial market integration of agricultural products has been widely used to indicate overall market performance (Faminow & Benson, 1990). In spatially integrated markets, competition among arbitragers will ensure that, a unique equilibrium is achieved where local prices in regional markets differ by no more than transportation and transaction costs. Information of spatial market integration, thus, provides indication of competitiveness, the effectiveness of arbitrage, and the efficiency of pricing (Sexton, Kling & Carman, 1991).

If price changes in one market are fully reflected in alternative market, these markets are said to be spatially integrated (Goodwin & Schroeder, 1991). Prices in spatially integrated markets are determined simultaneously in various locations, and information of any change in price in one market is transmitted to other markets (Gonzalez-Rivera & Helfand, 2001). Markets that are not integrated may convey inaccurate price signal that might distort producers' marketing decisions and contribute to inefficient product movement (Goodwin & Schroeder 1991), and traders may exploit the market and benefit at the cost of producers and consumers. In more integrated markets, farmers specialize in production activities in which they are comparatively proficient, consumers pay lower prices for purchased goods, and society is better able to reap increasing returns from technological innovations and economies of scale (Vollrath, 2003). Market integration of agricultural products has retained importance in developing countries due to its potential application to policy making. Based on the information of the extent of market integration, government can formulate policies of providing infrastructure and information regulatory services to avoid market exploitation.

In theory, spatial price determination models suggest that, if two markets are linked by trade in a free market regime, excess demand or supply shocks in one market will have an equal impact on price in both markets. Given the wide range of ways prices may be related, the concept of price transmission can be thought of as being based on three notions, or components (Balcombe & Morisson, 2002; Prakash, 1998). These are:

1. Co-movement and completeness of adjustment which implies that changes in prices in one market are fully transmitted to the other at all points of time;
2. Dynamics and speed of adjustment which implies the process by, and rate at which, changes in prices in one market are filtered to the other market or levels; and,
3. Asymmetry of response which implies that upward and downward movements in the price in one market are symmetrical or asymmetrical to the other. Both the extent of completeness and the speed of the adjustment can be asymmetric.

Within this context, complete price transmission between two spatially separated markets is defined as a situation where changes in one price are completely and instantaneously transmitted to the other price, as postulated by the Law of One Price (LOP) (Rapsomanikis, Hallam and Comforti, 2000). Specifically, the study: (i) determined the existence and level of inter-market price dependency; (ii) examined the speed of price adjustment to long-run equilibrium and (iii) examined the Granger Causality among rural and urban cereal grain markets.

Methodology

Sampling Procedure

Random sampling technique was adopted for the study. This was done in the selection of Adamawa, Gombe and Taraba States from the 6 states that made up the North-east geopolitical zone. Privilege information suggests that the data on rural and urban prices of agricultural commodities can only be obtained from the various states Agricultural Development Programmes offices. Because, all other organizations, such as the Central Bank of Nigeria and National Bureau of Statistics, record and publish data on agricultural commodities prices only at the urban levels. Also, the latest publication on agricultural commodity prices by the National Bureau of Statistics, as at the time of sourcing data for this research was for the period 1997-2006, hence, it is not up-to-date.

Data Collection

Only secondary data were used in the study. Secondary data on monthly bases for the prices of 100kg of three cereal grains, maize, rice and sorghum in both rural and urban markets in the study area were obtained from Adamawa, Gombe and Taraba States Agricultural Development Programme (ADPs) offices for a period of 10 years (2001-2010).

Model Specification

The sequence of the tests is as follows:

(i) For each pair of prices, we start by testing for the order of integration for each price utilizing the Augmented Dickey-Fuller (Dickey and Fuller, 1979). In the event that the series have a different order of integration I(0), we conclude that the prices are not integrated. We test for Granger Causality within a Vector Autoregression (VAR) framework to assess price transmission between the markets or along the supply chain.

(ii) In the event that the tests indicate that the series are integrated of the same order (say I(1)), we proceed by testing the null of non cointegration against the alternative hypothesis of one cointegrating vector using the Johansen procedure (Johansen 1988, 1991), or we test for the null of non cointegration following Engle and Granger (1987). Evidence against the null of no cointegration is taken to indicate that prices co-move and that markets are integrated. We do not impose and test for any restrictions on the cointegrating parameter estimate. Inference on the extent of price transmission based on the size of the parameter may be misleading. In the event that the null of non cointegration is not rejected, we conclude that the markets are not integrated.

(iii) In the event that tests indicate that the price series are cointegrated, we proceed by focusing on the error correction representation, in the form of a (V) ECM and on examining the short run dynamics, the speed of adjustment and the direction of Granger causality in the short or the long run following Granger (1969, 1988).

(iv) At the next stage, based on our results on the direction of causality, we discuss the results and comment on the nature of price transmission and market integration. It is important to note that the above testing framework does not identify the factors that affect market integration and price transmission.

Consider a Vector Autoregression (VAR) of two variables $p_{1t}$and p_{2t}. A VAR expresses a vector of variables as a linear sum of a set of lags of itself. A simple case of a VAR between two variables is:

$$\begin{pmatrix} p_{1t} \\ p_{2t} \end{pmatrix} = \begin{pmatrix} \mu_1 \\ \mu_2 \end{pmatrix} + \begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix} \begin{pmatrix} p_{1t-1} \\ p_{2t-1} \end{pmatrix} + \begin{pmatrix} V_{1t} \\ V_{2t} \end{pmatrix} \quad \ldots\ldots 1$$

The issue of cointegration can once again be addressed by looking at the VAR, but extending it to contain a second lag. An example of a VAR(2) would be

$$\begin{pmatrix} p_{1t} \\ p_{2t} \end{pmatrix} = \begin{pmatrix} \mu_1 \\ \mu_2 \end{pmatrix} + A_1 \begin{pmatrix} p_{1t-1} \\ p_{2t-1} \end{pmatrix} + A_2 \begin{pmatrix} p_{1t-2} \\ p_{2t-2} \end{pmatrix} + \begin{pmatrix} V_{1t} \\ V_{2t} \end{pmatrix} \quad \ldots\ldots 2$$

This has the Vector Error Correction (VECM) representation:

$$\begin{pmatrix} \Delta p_{1t} \\ \Delta p_{2t} \end{pmatrix} = \begin{pmatrix} \mu_1 \\ \mu_2 \end{pmatrix} + (A_1 + A_2 - I) \begin{pmatrix} p_{1t-1} \\ p_{2t-1} \end{pmatrix} + \begin{pmatrix} V_{1t} \\ V_{2t} \end{pmatrix} \quad \ldots\ldots 3$$

The rank of the matrix (A_1 + A_2 - I) is equal to the number of cointegrating vectors. If the rank of (A_1 +A_2 -I) is equal to two, then both variables can be shown to be stationary. If the rank of (A_1 +A_2 -I) is zero then the series are not cointegrated, whilst if the rank of (A_1 + A_2 - I) is one then the variables are cointegrated. Therefore, in the case of two variables, cointegration can be tested by testing the significance of the characteristic roots or eigenvalues of ($A_1 + A_2 - I$). If the variables are not cointegrated the characteristic roots λ_1, λ_2 are equal to zero. Similarly if the rank of ($A_1 + A_2 - I$) is equal to one, $0 < \lambda_1 < 1$ and λ_2 is equal to zero. Johansen (1988, 1991) derived the distribution of two test statistics for the null of no cointegration referred to as the Trace and the Maximum Eigenvalue test:

$$\lambda_{trace} = -T\Sigma_{i=1}^{2} \ln(1-\hat{\lambda}1) \ldots\ldots 4$$

$$\hat{\lambda}_{max} = -T ln(1-\hat{\lambda}_2) \ldots\ldots 5$$

The first statistic tests the null hypothesis that the number of independent cointegrating parameters is less than or equal to two, whilst the second statistic tests the null hypothesis that the number of co integrating parameters is one against an alternative of two cointegrating parameters.

Error Correction Representation of Cointegrated Equation or Systems

Johansen derived an Error Correction Representation of a cointegrating system. He defined two (n×r) matrices *a* and*b*, where n is the number of variables (in the case of price transmission exercise n equals 2) and r the rank of (A_1 + A_2 - I). The properties of these matrices are:

$$(A_1 + A_2 - I) = ab' \ldots\ldots 6$$

The matrix *b* is the matrix of cointegrating parameters, whilst the matrix *a* represents the adjustment of the variables towards the long run equilibrium, if it exists. In the case of two variables such as $p_{1t}$and p_{2t}, the error correction representation or Vector Error Correction Model (VECM) is as follows:

$$\begin{pmatrix}\Delta p_{1t}\\ \Delta p_{2t}\end{pmatrix} = \begin{pmatrix}\mu_1\\ \mu_2\end{pmatrix} + \begin{pmatrix}\alpha_1\\ \alpha_2\end{pmatrix}(p_{1t-1} - ßp_{t-2}) - A_2\begin{pmatrix}\Delta p_{1t-1}\\ \Delta p_{2t-1}\end{pmatrix} + \begin{pmatrix}V_{1t}\\ V_{2t}\end{pmatrix} \qquad \text{........ 7}$$

b represents the long run multipliers where a rank restriction has been imposed:

$$\frac{a_{12}}{1-a_{11}} = \frac{a_{21}}{1-a_{22}} = ß \qquad \text{........ 8}$$

In this case the lack of a cointegrating relationship would also imply no Granger causality between the series, but only if $A_2 = 0$. More generally, Granger causality does not require cointegration. However, cointegration does imply causality in at least one direction.

Result and Discussion

Existence and Level of Inter-market Price Dependency

Unit Root Tests

The result presented in Table 1 examines the time series properties of prices of maize, rice and sorghum in both rural and urban markets. The variables were examined for non stationarity using the Augmented Dickey-Fuller unit root test (Dickey & Fuller, 1979). The result of the ADF unit root test indicates that price of rice in the rural and urban locations were non stationary at their levels, but became stationary at the first order difference. Prices of maize in both locations were stationary at their levels. However, according to Obayelu and Salau (2009) at first differencing, a time series that has one unit root and another that has a double unit root can still be cointegrated, where the resulting linear combination is $I(1)$. That is to say, two or more integrated time series of any order can be cointegrated if there exist a linear combination of the two that is of a lower order of integration, e.g, $I(1) \rightarrow I(0)$ or $I(2) \rightarrow I(1)$ if this is true, the OLS estimator of the regression in the levels is consistent.

From the unit root test results, urban and rural prices of maize are stationary at levels (has no unit root) or in other word, market integration existed between the urban and rural price of maize. As reported by Rapsomanikis, Hallam and Comforti (2004), that in the event the series have a different order of integration such as $I(0)$, the series can be concluded to be stable at levels. This implies they can be estimated directly at their levels using the vector autoregressive (VAR) model and subsequent examination of whether Granger causality exists and in which direction. Urban and rural prices of rice were stationary after their first difference, thus, were integrated at order one $I(1)$ which necessitated the estimation of the vector error correction model (VECM). However, urban and rural prices of sorghum were $I(1)$ and $I(1)$ respectively in their natural form, which warranted their transformation to a log form (Obayelu & Salau, 2009). Then, they became stationary after first difference (integrated at order one), this implied that the variables were $I(1)$ and any attempt to specify the dynamic function of the variable in the level of the series will be inappropriate and may lead to problems of spurious regression in line with Mesike, Okoh and Inoni (2010). The econometric results of the model in that level of series will not be ideal for policy making (Yusuf & Falusi, 1999).

Table i: Augmented Dickey-Fuller Unit Root Test

Variable	Constant	Trend	Lag	ADF	95% critical value	ADF	95% critical value	Order
				Level		First difference		
(PM)urban	With	With	0	-5.5993	-3.4480	-	-	*I*(0)
(PM)rural	With	With	0	-6.1002	-3.4480	-	-	*I*(0)
(PR)urban	With	without	1	-2.7401	-2.8861	-9.5855	-2.8863	*I*(1)
(PR)rural	With	without	1	-2.1952	-2.8861	-8.5720	-2.8863	*I*(1)
Log(PS)urban	With	without	0	-2.5263	-2.8858	-9.6189	-2.8861	*I*(1)
Log(PS)rural	With	without	2	-2.1750	-2.8863	-8.6847	-2.8868	*I*(1)

Source: Field Data, 2001-2010

Impulse response function (IRF) for rural and urban price of maize

Short-run dynamics interrelationship between markets can be better observed by computing the impulse response function, which shows the persistent effect or asymmetric effect of shocks between related market prices (Goodwin & Harpper, 2000). The estimated coefficients of the VAR and contemporaneous model indicate the direct effects on the price of maize in urban and rural markets. Yet, we are also interested in the total effects (direct and indirect effects) that the price of maize in rural market will have on the urban price. Thus, in Figure 1 we present the results from the impulse response for the level of urban price of maize. The actual impulse response function was based on the above estimated model of the vector autoregressive (VAR) estimate using the actual data (Table 1).

An IRF traced the effect of a one-time shock to one of the innovations on current and future values of the endogenous variables. A shock to one variable, has not only directly affected another variable but is also transmitted to all of the other endogenous variables through the dynamic (lag) structure of the VAR. Our innovations were assumed to be contemporaneously uncorrelated after a transformation, and the numbers in parentheses are the response standard errors. The IRF results in Figures 11 and Table 11 traced out the response or described how the urban market price reacted over time to exogenous impulses (shocks) in the rural market price. The result on the table shows that urban market price of maize was affected contemporaneously by the shock to itself (first column) and also affected contemporaneously by the shocks from the rural counterpart (second columns). The response was also portrayed graphically, with horizon (period) on the horizontal axis and response on the vertical axis. From the table, the first column is the response of urban market price of maize to itself; the second column is the response of urban market price of maize to the rural price.

The urban price of maize responded to its own structural innovation and seemed to appear greater than the response of rural price. A market shock to urban market price of maize was stronger on itself at all horizons (from the first to the tenth months) and was less than the shock to rural price in all the periods. Also, urban price innovations played a larger role in explaining its response in short-run, than it did in the long-run. Indeed, for the ten period horizons, urban price of maize's shocks explained a greater proportion of the response of itself than the shocks from the rural price.

Overall, it appeared that, innovations in urban price of maize was an important contributors to variability of rural price either in the short or long-run, while as economic shocks to rural price of maize also contributed to the variability of urban price in the long run.

From the graph, let us consider the "Response of PMU to PMR." If we increase rural price for one time period, at time period 0, then the urban price will start to increase, and urban price will grow more quickly than other wise for about two months and then start to fade. In general, there was strong market integration between the urban and rural prices of maize.

Table ii: Vector Auto Regression Estimates for Urban/Rural Prices of Maize

Regressors	PMU	PMR
PMU(-1)	0.526228 (6.35562)	0.227754 (3.38986)
PMR(-1)	0.432536 (3.69446)	0.437497 (4.60509)
Constant	703.3857	1224.900
F-statistics	89.05751	55.92043

Source: Field Data, 2001-2010

Johansen Cointegration Test

Cointegration tests were conducted by using the recorded rank procedure developed by Johansen (1988) and Johansen and Juselius (1990). This method should produce asymptotically optimal estimates since it incorporates a parametric correction for serial correlation. The nature of the estimator means that the estimates are robust to simultaneity bias, and it is robust to departure from normality (Johansen, 1995). Johansen method detects a number of cointegrating vectors in non-stationary time series.

Johansen procedure was used to determine the rank r and to identify a long-run rural-urban markets price relationship of three different cereal grains. The number of lags used in this VAR is based on the evidence provided by the Akaike Information Criteria (AIC). However, cointegration between the prices means that the prices follow the same long-run trends, which they cancel in the price differentials. The existence of cointegration by itself does not imply which price equilibrium adjusts and which do not, nor does it entails whether any adjustment is fast or slow. Cointegration between the rice prices could arise, if the price differentials between two locations were stationary. However, cointegration at such does not say anything about the direction of causality.

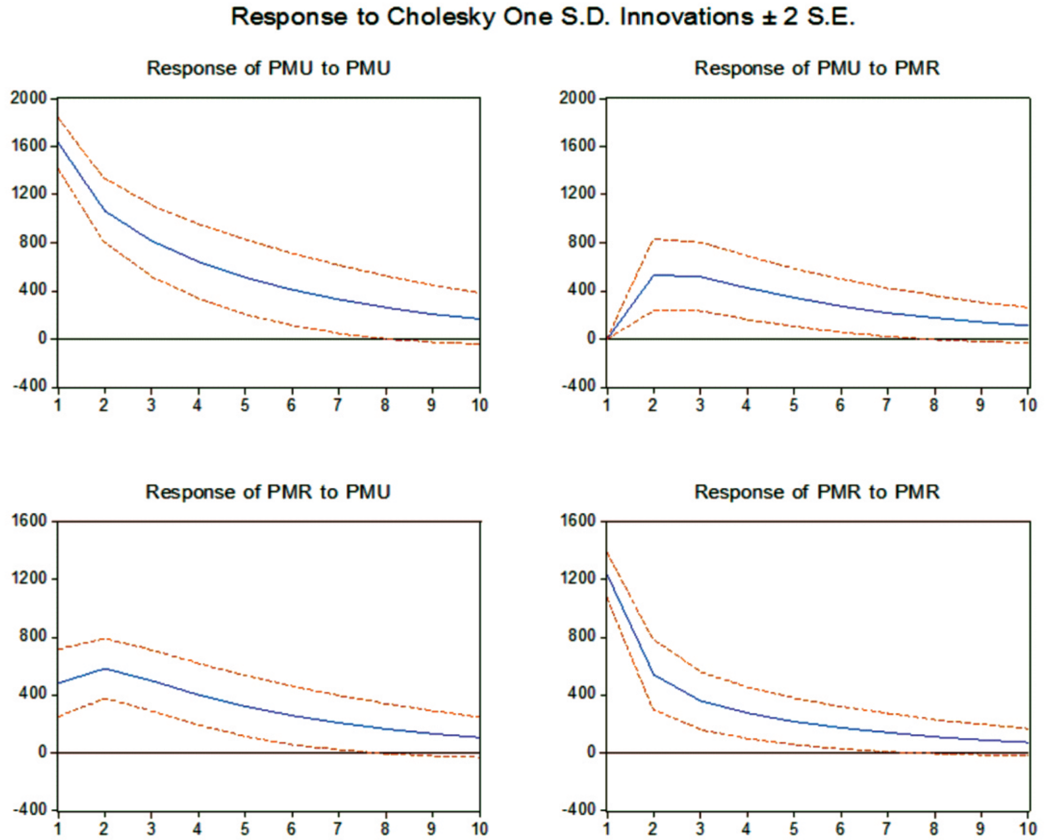

Figure 11: Graphs of the Impulse Response Function
Source: Field Data, 2001-2010

Unlike the Engle–Granger procedure that is based on Ordinary Least Square (OLS) estimate, Johansen vector auto regression relies on two maximum likelihood estimates, these are the trace statistic and max-eigenvalue, though the trace statistic is considered more reliable than the max-eigenvalue statistic (Tables 111, 1V and Tables V, V1). The trace statistic indicated no cointegration at $\rho < 0.05$.

Table iii: Eigen Values and Trace Statistic Test for Rice

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	5 Per cent Critical Value	1 Per cent Critical Value
None *	0.101350	18.77239	15.41	20.04
At most 1 *	0.050886	6.162705	3.76	6.65

*(**) denotes rejection of the hypothesis at the 5%(1%) level
Trace test indicates 2 cointegrating equation(s) at the 5% level
Trace test indicates no cointegration at the 1% level

Source: Field Data, 2001-2010

Table iv: Eigen values and Max-Eigen Statistic for Rice

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	5 Per cent Critical Value	1 Per cent Critical Value
None	0.101350	12.60968	14.07	18.63
At most 1 *	0.050886	6.162705	3.76	6.65

*(**) denotes rejection of the hypothesis at the 5%(1%) level
Max-eigenvalue test indicates no cointegration at both 5% and 1% levels

Source: Field Data, 2001-2010

Table v: Eigen Values and Trace Statistic Test for Sorghum

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	5 Per cent Critical Value	1 Per cent Critical Value
None **	0.155275	25.01746	15.41	20.04
At most 1 *	0.044079	5.274405	3.76	6.65

*(**) denotes rejection of the hypothesis at 5%(1%) level
Trace test indicates 2 cointegrating equation(s) at 5% level
Trace test indicates 1 cointegrating equation(s) at 1% level

Source: Field Data, 2001-2010

Table vi: Eigen value and Max-Eigen Statistic for Sorghum

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	5 Percent Critical Value	1 Percent Critical Value
None **	0.155275	19.74305	14.07	18.63
At most 1 *	0.044079	5.274405	3.76	6.65

*(**) denotes rejection of the hypothesis at 5%(1%) level
Max-eigenvalue test indicates 2 cointegrating equation(s) at 5% level
Max-eigenvalue test indicates 1 cointegrating equation(s) at 1% level

Source: Field Data, 2001-2010

Speed of Price Adjustment to Long-run Equilibrium
Rice
The cointegration equation is presented on Table V11, the cointegrating equation is given the equation for the change in urban price (first column) and change in rural (second column). The adjustment coefficient on CointEq1 (Table V11) for the urban price is negative (*a apriori*), insignificant and very small at 17.1% a month, the adjustment coefficient on rural price is positive, as it should be, but fairly large 59.2% a month, and significant. All the adjustment was being done by rural price of rice.

Table vii: Vector Error Correction for Long-run estimates for Rice

Regressors	Long-run estimates	Standard error	t-value
PRU	1.000		
PRR	-1.276030	0.26636	-4.791057
Constant	1252.744		

Source: Field Data, 2001-2010

Table viii: Vector Error Correction for Short-run estimates for Rice

Error Correction	D(PRU)	D(PRR)
CointEq1	-0.170725	0.592237
	(-1.86382)	(2.61099)
D(PRU(-1))	-0.27910	-0.319457
	(-2.74929)	(-1.26802)
D(PRR(-1))	-0.178996	-0.234610
	(-1.56664)	(-0.82923)
Constant	191.6992	193.7115

R-sq= 0.167541, 0.488167 for D(PRU) and D(PRR) respectively, Adj.R-sq= 0.145634, 0.474698 F-statistic, 7.647886, 36.24297, D = difference operator, Figures in parentheses are t-values, PRU = Urban Price of Rice, PRR = Rural Price of Rice
Source: Field Data, 2001-2010

Vector error Correction model Result and Interpretation for Rice
The results of the vector error correction estimate are presented on Table V11 and Table V111 for long and short-run estimates, respectively. The result of the short-run test indicated that, rural price of rice had a value of -0.178996 and long-run value of -1.276030. The result implied that, a 1% increase in urban price of rice in the short-run had increased the rural price by 18%, while in the long-run, rural price would increase by 127.6 %.

The Error Correction coefficient, the speed with which the system adjusted to shocks and restored equilibrium between the short and long-run, measured by the ECM was -0.170725 for the urban price and 0.592237 for the rural price. The model came out with the expected negative sign and also indicated that the speed of restoring equilibrium back into the system in response to exogenous shock was slow.

Further interpretation of the absence of cointegration between the two market prices implies that the two prices do not follow the same long-run trend. As a result, the market price in the urban market either drifted above or below the rural market price in the long-run, implying that urban market price either costs too much or rural market price cost less. This is not surprising, as Rashid and Minot (2010) highlighted that market locations lack integration due to inadequate public goods (such as infrastructure), inefficient flow of information, imperfect competition, and incomplete or missing institutions for risk management like credit and insurance- all of which qualify as sources of market failures. Taru and Lawal (2011) and Ndaghu and Taru (2012) have detected some of these indexes of market failures coincidently in the area covered by this study, and are likely to be responsible for the absent of integration in these markets. Nuhu et al. (2009) reported that the transportation system in Nigeria and indeed the north eastern part is not adequate. Most roads particularly those leading to the rural areas where farming activities are carried out are seasonal roads and are not motorable during the rainy season. Adeoye, Dontsop Nguezet, Badmus and Amao (2011), in a study of the integration of banana and plantain in rural and urban market in Oyo State found bad roads as the major factor responsible for market segmentation among markets. According to Olukosi and Isitor (1990), inaccessibility of producing rural areas to fast means of transportation results in location surpluses at the producing areas and shortages at the urban consuming areas making the rural and the urban markets segmented.

Sorghum

The cointegration equation for this model is presented on Table 1X, and following the cointegrating equation is given the equation for the change in urban price (first column) and change in rural (second column). The adjustment coefficient on Cointegration equation 1 for the urban price was negative as it should be, generally, low coefficient indicates slow adjustment and high coefficient indicates rapid adjustment, hence the coefficient was small (29.5%) a month and significant, the adjustment coefficient on rural price was positive, as it should be, but fairly small 38.0% a month, and significant. The adjustment is being done by both the rural price and urban price of sorghum. However, the rural price of sorghum adjusted faster, than the urban price.

In general, traders are perceived to be better informed than Farmers, and assertions that opportunities for the knowledgeable to "exploit" the less knowledgeable have been made by numerous researchers (Deomampo1983;Manuel &Maunahan1982; Olgado, Abunvawan & Domingo, 1977).These studies argued that asymmetric information, coupled with farmers' heavy reliance on traders for information, provide traders with market power and enable unscrupulous traders to manipulate prices to the disadvantage of the farmers. In the opinion of Mendoza and Rosegrant (1995), this impairs poor market integration. On the other hand, the absent of market integration implied imperfections in the market and a departure from competitive conditions. This according to economic theory provides a potential opportunity for middle men to realize excessive profits. Hay and McCoy (1977) noted however, that market segmentation may not only result from exploitative practices of traders but are likely to be as a result of the nature of production and defects in the marketing system.

Table ix: Vector Error Correction of Long-run estimates for Sorghum

Regressors	Long-run estimates	Standard error	T-value
LOG(PSU)	1.000		
LOG(PSR)	-1.002185	0.09050	-11.0743
Constant	-0.175882		

Source: Field Data, 2001-2010

Table x: Vector Error Correction of Short-run estimates for Sorghum

Error Correction	D(PSU)	D(PSR)
CointEq1	-0.29517	0.38034
	(-2.12564)	(2.65164)
DLOG(PSU(-1))	0.086645	0.070313
	(0.55397)	(0.43097)
DLOG(PSU(-2))	0.200324	-0.117872
	(1.44483)	(-0.81501)
DLOG(PSR(-1))	-0.181272	-0.285472
	(1.38375)	(-2.08910)
DLOG(PSR(-2))	-0.196370	-0.188395
	(-1.84776)	(-1.69945)
Constant	-0.008405	0.015556

R-sq= 0.057755, 0.264635 for D(PRU) and D(PRR), respectively, Adj R-sq 0.015312, 0.231510 for D(PRU) and D(PRR), Respectively, F-statistic, 1.360753, 7.989075 for D(PRU) and D(PRR), respectively, D = difference operator, CoinEq1 = cointegration equation, PSU = Urban price of sorghum, PSR = Rural price of sorghum, LOG = Logarithm.
Source: Field Data, 2001-2010

Vector error Correction model Result and Interpretation for Sorghum
The results of the vector error Correction estimate are presented in Tables X1 and X 4.16 for long and short-run estimates, respectively. The result of the short-run test indicated that, the rural price of sorghum had a short-run value of -0.181273 and long-run value of -1.002185. The result of the rural price indicated that a 1% increase in urban price of sorghum in the short-run had increased rural price by 18%, while in the long-run, rural price would increase by 100.2%.

The Error Correction coefficient, the speed with which the system adjusted to shocks and restored equilibrium between the short and long-run, measured by the ECM was -0.29517 for the urban price and 0.38034 for the rural price. The model came out with the expected negative sign for the urban market. The negative value of the adjustment parameter implies that positive deviations from the long-run equilibrium are corrected by decreases in prices in a particular market. It indicated that the speed of restoring equilibrium back into the system in response to exogenous shock was slow.

Further interpretation of the absence of cointegration between the two market prices implies that the two prices do not follow the same long-run trend. As a result, the market price in the urban market might have drifted above or below the rural market price in the long-run, implying that urban market price of sorghum either costs too much or rural market price costs less.

Granger-Causality among Rural and Urban Markets
Maize
Table xi indicates the direction of causality between urban price of maize and rural price of maize. The variables used in these tests were stationary at their levels. The Granger test was conducted with a lag length of $\rho < 0.005$ and $\rho < 0.05$. The result indicated that there existed an interdependent and bi-directional causality between urban price of maize and rural price of maize. An increased in rural price of maize led to an increased urban price of maize and vice versa.

It is important to note that although cointegration between two price series implies Granger causality in at least one direction, the opposite is not necessarily true. In this case, lack of cointegration between the two trending price series may indicate that market integration is absent, as other factors such as transaction costs, some price signals are passing through from one market to another. On the other hand, lack of Granger causality may not imply an absence of transmission, as price signals may be transmitted instantaneously under special circumstances.

From the results of the Augmented Dickey-Fuller unit root test, impulse response function, the speed of adjustment and Granger-Causality, inferences can be drawn that urban and rural market prices of maize obeys the Law of One Price (LOP), indicating that urban and rural markets of maize were efficient, non-collusive with an indication of perfect price matching.

Table xi: Pairwise Granger Causality Tests for Maize

	Observation	F-Statistics	Probability
RUMPM-URMPM	119	11.49117**	0.0007
URMPM-RUMPM	119	13.64907**	0.0002

**indicating a significance level of $\rho < 0.05$
Source: Field Data, 2001-2010

Rice
Table xii presents the direction of causality between urban price of rice and rural price of rice. The variables used in these tests were assumed to be stationary and well integrating. The Granger test was conducted with a lag length of 2 and 5% level of significance. The result indicated that, there existed no interdependence and any form of causality between urban price of rice and rural price of rice. An increased rural price of rice did not lead about an increase in the urban price of rice and vice versa. We conclude that the urban and rural prices of rice were inefficient, with an indication of collusive behaviour.

Table xii: Pairwise Granger Causality Test for Rice

	Observation	F-Statistics	Probability
RUMPR-URMPR	118	2.454352	0.1172
URMPR-RUMPR	118	1.607884	0.2048

Source: Field Data, 2001-2010

Sorghum

Table X111 indicates the direction of causality between urban and rural price of sorghum. The variables used in these tests were assumed to be stationary. The Granger test was conducted with a lag length of 2 and 5% level of significance. The result indicated that there existed no interdependence and bi-directional causality between urban price of sorghum and rural price of sorghum. An increased rural price of sorghum did not lead to an increase in the urban price of sorghum and vice versa. This conforms to the cointegration test, where the cointegration test found no cointegration equation, implying that they did not follow each other in the long-run trend.

Table xiii: Pairwise Granger Causality Test for Sorghum

	Observation	F-Statistics	Probability
RUMPS-URMPS	117	1.267137	0.5307
URMPS-RUMPS	117	3.544102	0.1700

Source: Field Data, 2001-2010

Conclusion and Recommendation

The study revealed that rural and urban prices of cereal grains were not cointegrated, this has led to the acceptance of the null hypothesis that cereal grains market are spatially independent and inefficient. This establishes the non-existence of Law of One Price (LOP) as against claims by previous studies that cointegration exist between rural and urban prices of agricultural commodities, though such conclusions were drawn based on the classical static linear regression and correlation analyses, and as such the findings were spurious. This is a vacuum which this study has fielded. Among the three commodities, only maize had shown a cointegration between its price in rural and urban markets, this is possibly as a result of no or little interference on the price of maize by the middlemen. Granger causality (unidirectional) existed between rural and urban prices of maize, while there was no Granger causality between rice and sorghum markets. The marketing and price information transmission mechanism for cereal grains marketing can be concluded inefficient.Extensions of the time-series analysis to test the effect of' structural variables such as density and quality of roads and bridges and penetration of extension and market services would help to identify the most productive investments, thus recommended.

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