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ANALYSIS OF SPATIAL PRICE VARIATION IN MAIZE AND SORGHUM MARKETING IN KADUNA STATE, NIGERIA

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ABSTRACT
The study analyzed spatial price variation in maize and sorghum marketing in Kaduna State. The data set for this analysis was monthly average secondary prices from 1999-2015. Data was analyzed using Augmented Dicker Fuller (ADF) test and Cointegration test and was performed using Stata 14.2 version of software. The results of the analysis showed that prices were found to be stationary at level and first difference and there is co-integration between the reference market and other markets. The equilibrium relationship between the price of maize and sorghum in Saminaka market and other markets was found to be positive. The speed of adjustment to the long run for sorghum between Saminaka-Giwa, Saminaka-Makarfi, and Saminaka-Godogodo was -1.08, -0.98 and -1.03 respectively, while that of maize was -1.98, -1.56, and -1.02. Implying that variation in prices are fully transmitted within a period of one month. It is recommended that government should ensure improvement of the operational environment of the marketers thereby drastically reducing transfer cost involved in the movement of grains across spatially separated markets.

Keywords: Co-integration, Spatial, Price variation, Maize, Sorghum.

INTRODUCTION
Maize is an important cereal food crop in Nigeria: it is the second most common cereal food crop after rice. It ranks third in the world production of cereal crops (Uchendu, 2020). Maize has been reported to have its wide utilization as a source of energy in the nutrition of human beings and livestock Obasi *et al.* (2012). Maize is also an important food crop in Nigeria due to its high yield potential, storability and diversity of uses. Sorghum is the fifth most important cereal crop grown in the world (U.S Grain Council, 2010). Probably because of its versatility and diversity (International Research Network, 2005).

Many economically important commodities are costly to transport. The spatial aspects of markets for such commodities cannot be ignored. Spatial price relationship generally refers to the factors that cause prices in one area to change in relation to those in another (Nuhu *et al*., 2009).

A market is spatially integrated when prices in each individual market respond to supply and demand of their market and that of other markets. The roles and conduct of traders in the determination of prices are interdependent among market within a state and between states. Transport cost is a major factor in marketing of food grains, spatial arbitrage ensures that the price difference between two markets will be in a long run, no greater than the transport cost.

Co-integration test is concerned with estimating long-run economic relationships among non-stationary and integrated variables. It allows capturing the equilibrium relationship

even between non-stationary series if such equilibrium relationship exists within a stationary model (Iroegbute *et al*., 2018). Co-integration analysis is used to test for price connections among the markets, it is used to determine the relationship between prices in different locations. When a long-run linear relation exists among different price series, these series are said to be co-integrated and if geographically separated markets are integrated, then there exists an equilibrium relationship among them.

Spatial patterns of marketing give rise to a complex web of relationship among prices throughout a market. In spite of the impressive growth in grain production over the past years and the position it occupies in addressing rural hunger employment and income generation, stakeholders continue to pay less attention to food grains marketing system. Weak infrastructure, poor transport facilities, poor storage and inefficient pricing system renders the system uncompetitive.

There have been a number of studies on food grain marketing with very little empirical knowledge on spatial variation in market prices of food grains in Kaduna State. The dichotomous nature of the area of surplus and deficit of maize and sorghum supply in Nigeria permit a study of this nature. The objective of this paper is to analyze the nature of spatial variations in market prices of maize and sorghum in the study area.

MATERIALS AND METHODS

Kaduna State lies in the north western part of the country's geopolitical zone. The State lies between latitudes $09^{0}02^{'}$N and $11^{0}32^{'}$ and longitudes $06^{0}15^{'}$E and $08^{0}50^{'}$. The State occupies an area of approximately 48,473.2 Square Kilometers and has a projected population of 9,032,200 million based on the annual population growth index of 3.2% (NBS, 2021). The State has 23 local government areas. The mean annual rainfall shows a marked decrease from South to North (1,524mm to 1635mm), which favors crop and livestock production.

Secondary data covered the wholesales monthly prices for 204 months (i.e., from 1999-2015) which were obtained from the Agricultural Development Programme (ADP) office and National Agricultural Extension Research and Liaison Services (NAERLS), ABU Zaria. The data collected focused on maize and sorghum grains which are some of the major food grains produced and traded in the study area where detail prices over time period are available.

Statistical analysis

The study was analyzed using Augmented Dicky fuller test (ADF), Error correction model (ECM) and Co-integration techniques.

Model specification

Testing for Unit Root

A variable is said to have a unit root if it is non-stationary (Vavra and Godwin, 2005). A time series that has a unit root is known as a random walk. A variable is said to contain a unit root or is 1 (1) if it be non-stationary

$$y_t = \beta y_{t-1} + E_t \quad \ldots(1)$$

If equation (1) equals one, the model is said to be characterized by unit root (the equation becomes the random walk model). For a series to be stationary, must be less than unity in absolute value hence, stationary requires that $-1 < \beta < 1$. The reason for unit root is to determine whether the series is consistent with 1(1) (integrated order of one) process with a stochastic trend.

Augmented Dickey Fuller Test (ADF)

$$\Delta Pit = \beta + \beta i\ T + \square i\ Pt\text{-}1 + \sum^{k}_{j=1} b1 \Delta Pit\text{-}1 + Et \quad \ldots(2)$$

where**;**

Δ = the difference operator

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T = time trend
β = drift parameter
βi, □I and bi = coefficients
Et = error term. (Dickey and Fuller, 1979)

Co-integration technique

Co-integration is a recent econometric technique that has been applied successfully to integration questions in marketing and financial studies (Trotter, 1992). It is concerned with estimating long-run economic relationships among non-stationary and integrated variables. It allows capturing the equilibrium relationship even between non-stationary series 9if such equilibrium relationship exists within a stationary model (Vavra and Godwin, 2005). In order to study the interdependence of prices between any pair of markets j, and I the two series would be expressed in form of the following regression equation

$Pi_t = \alpha + \beta Pj_t + Ui_t$ …(3)

where**;**

Pi_t = price of the commodity at time t and location i (e.g.**,** local market
Pj_t = price of the commodity at time t and location j (e.g.**,** regional market)
α = intercept term
β = slope coefficient
Uit = error term

RESULTS AND DISCUSSION

Optimal Lag Selection for The Unit Root Test

Table 1 presents the Vector Autoregression (VAR) estimates of the optimal number of lags for conducting unit root test on all the price series based on three criteria. It was found that the optimal number of lags to be retained in conducting unit root test on all the price series in all the markets, irrespective of the market type was 2. When at least two criteria jointly selected a particular number of lags, that specific number of lags was considered as the optimal lag number. Therefore, following this procedure, there was consistency in what was considered as the optimal lag for the price series. In fact, all the three criteria chose 2 as the optimal number of lags, irrespective of the market type, except in Godogodo, where AIC chose 3 as the optimal number of lags. Thus, the unit root test was conducted using 2 as the optimal lag in the following section.

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Table 1: VAR Estimates of the Optimal Number of Lags for Unit Root Test Based on Market's Type and Across markets' Couples

	Market's type							
	Maize				Sorghum			
Markets couples	**AIC**	**HQIC**	**SBIC**	**Decision**	**AIC**	**SBIC**	**HQIC**	**Decision**
Saminaka	2	2	2	2	2	2	2	2
Giwa	2	2	2	2	2	2	2	2
Makarfi	2	2	2	2	2	2	2	2
Pambegua	2	2	2	2	2	2	2	2
Kawo	2	2	2	2	2	2	2	2
Birnin\gwari	2	2	2	2	2	2	2	2
Godogodo	2	2	2	2	3	2	2	2
Jagingi	2	2	2	2	2	2	2	2

Source: Author's estimates (2016)
SBIC = Schwarz's Bayesian Information Criterion, AIC = Akaike's Information Criterion; HQIC = Hannan and Quinn Information Criterion.

Unit Root Test of the Price of Maize and Sorghum

The unit root test analysis was conducted using two test-statistics namely the Phillip-Perron (PP) test and the Augmented Dickey-Fuller (ADF) test using a maximum lag of 2. The null hypothesis for both tests is that the price series contain a unit root; that is, they are stationary while the alternative hypothesis is that the price series contain at least a unit root; that is, they are non-stationary. Based on PP, the findings in Table 2 suggest that all the price series of sorghum were found to be non-stationary as all the t-statistics were statistically significant at either 5 percent or 10 percent level of probability. However, according to the ADF test, only the price of sorghum in Godogodo market was found to be non-stationary. The price of maize across the eight markets was non-stationary given the significance of all the test-statistics.

Table 2: Unit Root Test of the Price of Maize and Sorghum at Level

	Sorghum				Maize			
	PP		ADF		PP		ADF	
Market	**t-stat**	**p-value**	**t-stat**	**p-value**	**t-stat**	**p-value**	**t-stat**	**p-value**
Saminaka	-3.74	0.022	-2.88	0.172	-4.05	0.009	-4.2	0.005
Giwa	-3.79	0.019	-2.86	0.179	-4.07	0.008	-4.24	0.005
Makarfi	-3.83	0.017	-2.85	0.182	-4.14	0.007	-4.31	0.004
Pambegua	-3.73	0.023	-2.92	0.159	-4.06	0.008	-4.19	0.006
Kawo	-3.87	0.015	-2.98	0.141	-3.96	0.012	-4.15	0.006
Birnin\g	-3.87	0.015	-2.91	0.162	-4.08	0.008	-3.44	0.049
Godogodo	-5.67	0.001	-3.86	0.016	-4.24	0.005	-3.53	0.039
Jagingi	-3.87	0.015	-2.94	0.154	-4.19	0.006	-3.46	0.046

Source: Author's estimates (2016)
ADF=Augmented Dickey-Fuller, PP=Phillip-Perron

However, in Table 3, both unit root tests consistently suggest that the price of sorghum and maize were stationary at first difference across all the eight markets. The implication of

these findings is that by studying the relationship between the price series using regression analysis would not be spurious but meaningful. Furthermore, given that all the price series are practically stationary at level; that is, integrated of order zero, standard tests of cointegration such as the Engle-Granger Test and the Johansen test would be inappropriate. This agrees with the finding of Iroegbute *et al*. (2018) who reported that stationarity was achieved at levels and at first differencing.

Table 3: Unit Root Test of the Price of Maize and Sorghum at First Difference

	Sorghum				Maize			
	PP		ADF		PP		ADF	
Market	**t-stat**	**p-value**	**t-stat**	**p-value**	**t-stat**	**p-value**	**t-stat**	**p-value**
Saminaka	-20.86	0.001	-20.15	0.001	-18.86	0.001	-17.66	0.001
Giwa	-21.42	0.001	-20.66	0.001	-18.71	0.001	-17.49	0.001
Makarfi	-22.29	0.001	-21.08	0.001	-18.85	0.001	-17.69	0.001
Pambegua	-20.49	0.001	-19.62	0.001	-18.64	0.001	-17.46	0.001
Kawo	-20.82	0.001	-20.12	0.001	-18.70	0.001	-17.63	0.001
Birnin\g	-21.14	0.001	-20.23	0.001	-19.51	0.001	-18.26	0.001
Godogodo	-26.21	0.001	-21.23	0.001	-20.06	0.001	-18.32	0.001
Jagingi	-21.15	0.001	-20.13	0.001	-19.59	0.001	-18.26	0.001

Source: Author's estimates (2016)
ADF=Augmented Dickey-Fuller, PP=Phillip-Perron

Cointegration Analysis of Maize and Sorghum Markets

Table 4 presents the result of the bound test analysis. Based on the Breusch-Godfrey (GB) test, it can be suggested that the RDL models for both maize and sorghum markets were free from serial correlation, therefore suggesting that the fitted models are valid. Based on the confidence interval provided by Pesaran *et al*. (2001) under the assumption of unrestricted intercept and no trend component, the F-statistic estimates were found to be statistically significant at various levels of significance when compared with the bound-statistic estimates; that is, there is a long run relationship between the price of maize in the Saminaka market and the price of maize in Giwa, Makarfi, Godogodo and Jagingi markets. The result also indicates that there is an equilibrium relationship between the price of sorghum in Saminaka market and the price of sorghum in Giwa, Makarfi and Godogodo markets. Similar observations were made by Odipo *et al*. (2014) who reported that since the null of a unit root was rejected; Kisumu and Machakos sugar markets were therefore co integrated.

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Table 4: Bound Test of Cointegration of Maize and Sorghum Market Across Market Couples

Markets couples	Market			
	Sorghum		Maize	
	BG-test[1]	Bound-test[2]	BG-test[1]	Bound-test[2]
Saminaka-Giwa	1.95	4.86**	2.31	4.1**
	(0.16)	(0.009)	(0.12)	(0.02)
Saminaka-Makarfi	2.33	5.71***	0.41	5.49***
	(0.13)	(0.004)	(0.52)	(0.005)
Saminaka-Godogodo	0.42	19.02***	0.001	6.39***
	(0.51)	(0.001)	(0.97)	(0.002)
Saminaka-Jagingi			0.01	4.71**
			(0.92)	(0.01)

Source: Author's estimates (2016)
Note: ***<0.01, **<0.05 and *<0.1. BG=Breusch-Godfrey. Upper bound value is 4.84 from the Pesaran table. (2.17, 3.19), (2.72, 3.83) and (3.88, 5.30) are the lower and upper bound F-statistics at 10%, 5% and 1% level of significance assuming no intercept and no trend. 1= Values in this column are chi-squared values. 2=Values in this column are F-statistic estimate for the null hypothesis that there is no long run relationship. Values in brackets are p-values.

Long-run Relationship Analysis

Table 5 shows that the equilibrium relationship between the price of maize and sorghum in Saminaka market and the price of maize and sorghum in the other markets is positive, which suggests that an increase in the price of maize and sorghum in Saminaka market would result to an increase in the price of maize and sorghum in the other markets. The price of sorghum between Saminaka-Giwa, Saminaka-Makarfi and Saminaka-Godogodo is elastic; that is, an increase in the price of sorghum in Saminaka market will result in more than a proportionate increase in the price of sorghum in Giwa market, Makarfi market and Godogodo market. This finding equally suggests that variations in price of sorghum in Saminaka market are fully transmitted in the long run to Giwa market, Makarfi market and Godogodo market. However, variation in the price of maize in Saminaka market is incompletely transmitted to Giwa market, Makarfi market, Godogodo market and Jagindi market. This agrees with the finding of Layade and Adeoye (2014) who reported that there is significant existence of long run market relationship between rural and urban onion markets in Oyo State.

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Table 5: OLS Estimates of the Long Run Relationship Across Market Couples

Markets couples	Sorghum	Maize
Saminaka-Giwa	1.04***	0.94***
	(334.19)	(265.62)
Saminaka-Makarfi	1.06***	0.92***
	(236.87)	(237.1)
Saminaka-Godogodo	1.02***	0.88***
	(47.27)	(126.74)
Saminaka-Jagindi		0.87***
		(140.12)

Source: Author's estimates (2016)
Note: ***<0.01. Prices series are in natural logarithm. Values outside and inside the brackets are long run regression coefficients and t-values respectively.

Analysis of the Speed of Adjustment of Prices

As expected, the sign of the Error Correction Term (ECT) was negative and statistically significant, confirming once more the earlier findings of the existence of long run relationship between the price of maize and sorghum in Saminaka market and other markets. In the sorghum market, the speed of adjustment between Saminaka-Giwa, Saminaka-Makarfi and Saminaka-Godogodo was -1.08, -0.98 and -1.03, respectively (Table 6). This suggests that variations in the price of sorghum in Saminaka market are fully transmitted within a period of one month to Giwa market and Godogodo market. But, variations in the price of sorghum in Saminaka market are transmitted at the rate of 98 percent monthly to Makarfi market, therefore suggesting that it takes about a month and 2 days for changes in price of sorghum in Saminaka market to be fully transmitted to Makarfi market.

Table 6: OLS Estimates of the Speed of Adjustment

	Sorghum		Maize	
Markets couples	**BG-test**	**ECT**	**BG-test**	**ECT**
Saminaka-Giwa	0.48	-1.08*	1.17	-1.98**
	(0.49)	(0.07)	(0.28)	(0.02)
Saminaka-Makarfi	2.17	-0.98**	0.39	-1.56**
	(0.14)	(0.03)	(0.54)	(0.04)
Saminaka-Godogodo	0.17	-1.03***	0.69	-1.02**
	(0.68)	(0.001)	(0.41)	(0.01)
Saminaka-Jagindi			0.56	-0.80*
			(0.46)	(0.07)

Source: Author's estimates (2016)
Note: ***<0.01, **<0.05, *<0.1. Prices series are in natural logarithm. Values outside and inside the brackets are long run regression coefficients and t-values respectively.
ECT=Error Correction Term

The speed of transmission (Table 6) of the price of maize to long run disequilibrium between Saminaka-Giwa, Saminaka-Makarfi, Saminaka-Godogodo and Saminaka-Jagindi is -1.98, -1.56, -1.02 and -0.80, respectively. This suggests that changes in the price of maize

in Saminaka market are fully transmitted within a month to Giwa, Makarfi and Godogodo markets while the transmission to Jagindi market is at the rate of 80 percent per month. In other words, it takes about a month and 3 weeks for changes in the price of maize in Saminaka market to be fully transmitted to Jagindi market. This agrees with the finding of Akintunde *et al*. (2012) who reported that price transmission occurs from urban to rural and not vice versa.

CONCLUSION AND RECOMMENDATIONS

Analysis of spatial aspects of price efficiency showed that there exists a long run relationship between the prices of maize and sorghum in the reference markets and other markets and that the equilibrium relationship is positive, which suggests that an increase in the price of maize and sorghum in Saminaka market would result to an increase in the price of maize and sorghum in the other markets. Government should ensure improvement of the operational environment of the marketers through the rehabilitation of feeder roads as well as construction of new roads to aid easy access to rural markets thereby drastically reducing transfer lost involved in the movement of grains across spatially separated markets.

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