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Spatial market integration of cowpea (*Vigna unguiculata*) in Adamawa state, Nigeria

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Abstract

The study was conducted to investigate agricultural price transmission across space and time of cowpea in Taraba State, Nigeria. Secondary data was the main sources of data which was collected from the prominent market in the State on weekly basis for the period of 16 months (between November 2021 to February 2022). Purposive sampling technique was adopted for the selection of cowpea markets on the basis of production output and market activities. Inferential statistics were used as analytical tools which involved the use of Augmented Dickey Fuller (ADF) test, Johansen Co-integration Model, Granger Causality tests and Vector Error Correction Model (VECM). The results of the study indicates that price of cowpea in the study area were stationary at first order of difference at 5% significant level. The result of Johansen cointegration analysis was based on trace statistics, which revealed high existence of co-integration among the market pairs in the study areas. The analysis of the study reveals that there exist bidirectional and unidirectional causality between cowpea markets. The study confirms the existence long run relationship running from Sabon Kasuwan Mubi to other market and also the existence of short run relationship among the market pairs in the study area. The study concludes that there is a strong co-integration between cowpea markets in Taraba State due to efficient free flow of price signals and market information between market pairs. Cowpea markets in the research area have a long-run and short run dynamic. It is therefore, recommended that government should make market infrastructure a priority in the State by providing storage facilities and a robust transportation system.

Key words: Agricultural; Price Transmission; Space and Time; Cowpea

1. Introduction

Nigerian climate is ideal for the development and production of cowpea (*Vigna unguiculata L. Walp*), often known as beans. It is a popular and inexpensive food crop with inelastic demand in Nigerian markets. Bean intake is an economical staple meal in most homes due to its possible health advantages in terms of protein content and the various forms it can be processed into [6] and [22]. Nigeria is the world's largest producer and consumer of beans, accounting for over 46% of worldwide production [13]. Producers throughout the world face wide price fluctuations, market price is a critical determinant in the supply and demand for commodities, such as in the bean market. Price volatility, according to [3], generates a lucrative channel that draws market participants. However, the magnitude of price elasticity, which affects the level of market integration across space, is a point of debate. As a result, the key reasons of price volatility in agricultural commodity markets have been identified as output seasonality, natural shocks, bargaining strength, and responsiveness to price fluctuations [8]. Pricing volatility is also caused by price insecurity and external impacts from non-official actors [9]. Cowpea marketing, like every other business, entails the long-term success of all commercial operations involving the flow of cowpea from the point of original agricultural production to the final consumer's hands [23]. Because of the high economic worth of the commodity, marketing cowpea is a successful business for most farm produce merchants. Cowpea marketing often yields a significant economic return due to its importance in most people's diets [11]. The challenge for marketers, on the other hand, is to meet consumers' desires while maintaining a respectable

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profit margin and acting in a respectable manner [18]. Cowpea marketing in West Africa is taking shape as a well-established hierarchical trade relationship, particularly between Nigeria and its neighbours [19].

The importance of a well-structured and well-organized market system cannot be overemphasized. It accelerates economic growth by fostering specialization, foreign exchange profits, the creation of an exchange economy, and the supply of income and job possibilities for marketing agents [6]. Essentially, an effective marketing system is one that has perfect market integration and full price transmission, as well as immediate price adjustments in response to changes within or outside the system [24]. Producers, intermediaries, and consumers in the marketing chain would all maximum profit from such a system. It would also help to eliminate unprofitable arbitrage and the isolation of spatially differentiated markets, as well as assure optimal resource allocation across space and time [24]. The co-movement of prices and/or flows between markets is referred to as market integration. It describes the interactions between two spatially separated marketplaces in general. A well-integrated market system is necessary not only for efficient allocation of productive resources, but also for the reduction of pricing risks that threaten economic actors' well-being, particularly the poor and food insecure households [10]. This is because the strength of price signals communicated between different market levels is crucial to the effectiveness of market changes [31].

Global food prices continue rising, posing a severe danger to political and economic stability, particularly in underdeveloped nations. Food prices rose by 65 percent between 2008 and 2013, causing riots in Burkina Faso, Cameroon, Egypt, Indonesia, Cote d'Ivoire, Mauritania, Mozambique, Senegal, and Zimbabwe, among other countries. The World Bank has identified 33 nations that are in danger of civil unrest as a result of rising food prices [29] The effectiveness of the market price system is critical to the sustainability of agricultural activities. In recent years, Nigeria's agricultural commodity market has displayed a pattern of long-term price declines and short-term price volatility [32 and 8] The price volatility of agricultural commodities in Nigeria, particularly cowpea, has been attributed to a number of factors, including differences in consumer bargaining power, cyclical income fluctuation among sellers and consumers, seasonality of production, natural shocks such as floods, pests, and diseases, and farmers' inappropriate response to price signals [14, 30, and 2).

As a result, one of the most important drivers of the quantity of agricultural commodities given by farmers and required by customers is agricultural commodity pricing. Agricultural commodity price volatility is a common occurrence in Nigeria [33 and 34]. Inconsistent agricultural commodity pricing between marketplaces might harm the marketing system and the economy as a whole. Depending on the source of unpredictability, it might result in inefficient resource allocation among vendors and customers. It may also exacerbate poverty among society's low-income earners [28]. Producers, marketers, consumers, and policymakers in both developed and emerging nations like Nigeria need information on agricultural commodity prices and their trends since understanding the trend of such fluctuations is critical for successful planning [37]. In agricultural commodity markets, poor knowledge of market prices and other structural flaws have been held responsible for inefficiency, but the role of information in pricing and the dynamic process of information transmission between markets in price discovery, as well as its implications for marketing efficiency, are critical for efficient commodity markets [21 and 35].

2. Materials and methods

2.1. Study Area

Adamawa state is a state in the North-East geopolitical zone of Nigeria, bordered by Borno to the northwest, Gombe to the west, and Taraba to the southwest, while its eastern border forms part of the national border with Cameroon. It takes its name from the historic emirate of Adamawa, with the emirate's old capital of Yola, serving as the capital city of Adamawa state [15]. Of the 36 states in Nigeria, Adamawa state is the eighth largest in area, but the thirteenth least populous with an estimated popupation of about 4.25 million as of 2016 *Pulse.ng; 2017.* Geographically, the state is mainly composed of the highlands of mountains (the Atlantika, Mandara, and the Shebshi ranges) and the Adamawa Plateau, crossed by valleys and rivers, most notably the Benue and Gongola rivers. As an agriculturally-based state, the Adamawa State economy mainly relies on livestock and crops, such as cotton, groundnuts, millet, cassava, guinea corn, and yams. After years of the Boko Haram insurgency affecting development in the state, Adamawa has the eleventh lowest Human Development Index in the country but as the insurgency has abated since 2016, development has renewed.

2.2. Source and method of data collection

For one year and four months, weekly retail prices of white cowpea were evaluated. The data was gathered from a prominent market in the State. The study took place between November 2021 and February 2022, making 16 months.

2.3. Sampling Procedure/Techniques

Purposive sampling technique was adopted for the selection of cowpea markets on the basis of production output and market activities. Selection of markets involved three stages. Adamawa State was purposely selected due to its importance in cowpea production and marketing. Finally, nine markets were purposely selected from Adamawa State.

2.4. Analytical tools

Inferential statistics were used as analytical tools. This involved the use of Augmented Dickey Fuller (ADF) test, Johansen Co-integration Model, Granger Causality tests and Vector Error Correction Model (VECM).

2.4.1. Augmented Dickey Fuller (ADF) test

The data was subjected to an Augmented Dickey-Fuller for unit root test in order to determine the stationarity series in the data, as expressed below;

$$\Delta P_{it} = \alpha + \gamma T + \zeta P_{it-1} + \Sigma_{i=1}^{n} \lambda_i \Delta P_{it-1} + \varepsilon_{it}, \quad (1)$$

Where;

P_{it} = price series investigated for stationarity;
t = the time horizon;
T = deterministic trend;
ε_t = white noise;
n = the number of lags required to make the error term uncorrelated; and
α, γ, *ζ* and λ are coefficient vectors.
The co-integration test was conducted if the unit root test validates the presence of a unit root at level or first difference in the price series.

2.4.2. Johansen Co-integration Model

To establish if the markets are co-integrated, the Johansen multivariate co-integration test was applied. At least one co-integrating connection must exist for the evaluation of a long-run link between prices to be viable as specified by [17] as:

$$\Delta P_{t=} \theta D_t + \Pi P_{t-1} + \Sigma_{i=1}^{k-1} \Gamma_i \Delta P_{t-1} + \varepsilon_t, \quad (2)$$

Where;
P_t = vector of I(1) endogenous variables;
θ = the matrix of the coefficient to be estimated;
Γ_i = matrices of the short-run parameters;
D_t = the vector of deterministic variables;
Δ = the difference operator;
k denotes the lag length;
ε_t = the disturbance term, which is independently and identically distributed (iid);
Π = the impact matrix, which contains information about the long-run relationships.

If rank (Π) = 0, the variables are not co-integrated, but if rank (Π) = *n*, the variables are stationary. However, if 0 < rank (Π) = *r* < *n*, the variables are co-integrated and can be represented in a VECM in their first differences

2.4.3. Granger Causality test

To examine if price changes follow established patterns, the Granger causality test was used. This test is one of the most important econometric methods for determining if previous changes in a time-series variable, such as "X," have an impact on the present variable, "Y," or whether the link is bilateral. If it can be confirmed (usually through a series of tests on lagged values of X, with lagged values of Y also included) that those X values provide statistically significant information about future values of Y, then a time-series X is said to show Granger causality with another Y For this investigation, we used Granger causality testing model for this analysis, derived from [20] but modified as follows;

$$lnP1t = \psi 0 + \sum ni{=}1 \psi 1 i lnP1(t-i) + \sum ni{=}1\ \psi i lnP_2(t-i) + \Sigma in{=}1 \vartheta i lnP_n(t-i) + \varepsilon t, \quad (3)$$

$$lnP2t = \vartheta 0 + \Sigma in{=}1\ \vartheta 1 i lnP1(t-i) + \Sigma in{=}1 \vartheta i lnP_2(t-i) + \Sigma in{=}1 \vartheta i lnP_n(t-i) + \varepsilon t, \quad (4)$$

$$lnPnt = \vartheta 0 + \Sigma in{=}1\ \vartheta nilnPn(t-i) + \Sigma in{=}1\vartheta ilnP_n(t-i) + \Sigma in{=}1\vartheta ilnP_n(t-i) + \varepsilon t \quad (5)$$

Where;

P_{1t} = price in market 1;
$P_{1(t-i)}$ = lagged prices of market 1;
P_{2t}= price in market 2;
$P_{2(t-i)}$ = lagged prices of market 2;
$P_{n(t-i)}$ = lagged prices of market n^{th};
P_{nt}= price in market n^{th};
$\psi_i's\ and\ \vartheta_i's$ = parameters to be estimated;
n = the numbers of lags; and
ε_t = the error term.
The market that Granger-causes the other is tagged the exogenous market or the lead market.

2.4.4. Vector Error Correction Model (VECM)

To evaluate the speed of adjustment of prices amongst the markets that co-integrate from long estimate, a vector error correction model (VECM) was established and the error-correction term was obtained. A specification of ECM is the most efficient way of representing the long-run equilibrium properties of the system, and the nature of the adjustment towards equilibrium (Engle and Granger 1987).

$$\Delta lnP_{it} = \tau_0 + \Sigma_{i=1}^{n}\tau_{1i}\Delta lnP_{i(t-i)} + \Sigma_{i=1}^{n}\tau_{2j}\Delta lnP_{j(t-i)} + \phi ECM_{(t-1)} + \varepsilon_{1t} \quad (6)$$

$$\Delta lnP_{jt} = \omega_0 + \Sigma_{i=1}^{n}\omega_{1i}\Delta lnP_{i(t-i)} + \Sigma_{i=1}^{n}\omega_{2j}\Delta lnP_{j(t-i)} + \phi ECM_{(t-1)} + \varepsilon_{2t} \quad (7)$$

Where;

P_{it} and P_{jt} = price series of markets
i and *j*; Δ = the difference operator;
$_{(t-1)}$ and $_{(t-1)}$ = lagged prices in markets *i* and *j*;
$\tau_0\ and\ \omega_0$ = constants; ω_i and τ_j = short-run coefficients; and
ECM = the error-correction term measuring the speed of adjustment from the short-run state of disequilibrium to the long-run steady-state equilibrium (Nyongo, 2013).

3. Results and discussion

3.1. Stationarity test

Table 1 ADF Unit root test results

Markets	At level	First difference	5% critical value
SKM	-0.240874	-9.432722**	-1.946549
KDM	-0.266178	-9.968802**	-1.946549
MHM	-0.225374	-6.867211**	-1.946549
SKG	-0.232894	-9.044123**	-1.946549
SMKT	-0.267766	-8.954157**	-1.946549
YNMKT	0.090265	-3.051523**	-1.946549
GMKT	-0.174366	-8.835817**	-1.946549
GNMKT	-0.394141	-9.230304**	-1.946549
LLMRK	-0.349837	-7.027057**	-1.946549

Source: Data analysis, 2022; ** denotes significant at P<0.05 level.; Note: KDM= Kasuwan Dole Mubi, SKM= Sabon Kasuwan Mubi, MHM= Maiha Market, SKG= Sabon Kasuwan Gombi, SMKT= Song Market, YNMKT= Yola North Market, GNMKT= Ganye Market, GMKT= Guyuk Market and LLMKT = Lamorde Lafiya Market.

The results of ADF presented in Table 1 below examined the time series properties of cowpea markets price. The variables were examined for non-stationarity. The results indicates that price of cowpea in the study area were non-stationary at their level, but became stationary at first order of difference, meaning that the market pairs were integrated of order 1, that is to say I(1). This is one of the conditions for testing integration that depicts the existence of a long run relationship among the five (5) cowpea markets in the study area. This study is in line with findings of [27] who showed that all the price series (RWB, RBB, UWB, and UBB) in both rural and urban markets were stationary at the first difference I(1) and also [20 and 3] observed that.

3.2. Johansen Test for Co-integration

Table 2 shows the results of co-integration analysis using Johansen multivariate analysis. The result was based on trace statistics indicates seven (7) cointegrating equations at the 0.05 level. This denotes that there is very high existence of co-integration among the market pairs in the study areas. Therefore, the null hypothesis of zero co-integrating linear equation among the market pairs was rejected. It then follows that price signal are transmitted across these markets, and therefore, any shock occurring in one market transmits signal to another market. This study supports [5] findings who reported that there is a strong and stable price linkage in onion markets, with the price in one market being able to predict prices in other markets in Nigeria.

Table 2 Results of Johansen Co-integration Test

Null Hypothesis	Trace statistics	5% critical value	P-value
r = 0	278.8596	197.3709	0.0000**
r ≤ 1	214.0720	159.5297	0.0000**
r ≤ 2	156.5858	125.6154	0.0002**
r = 3	104.7933	95.75366	0.0103**
r ≤ 4	72.68692	69.81889	0.0290**
r ≤ 5	50.64814	47.85613	0.0267**
r = 6	30.19158	29.79707	0.0450**
r ≤ 7	10.86973	15.49471	0.2196
r ≤ 8	2.177320	3.841466	0.1401

Source: Data analysis, 2022; ** denotes rejection of the null hypothesis at 5% level of significant.

3.3. Granger Causality Test

Since co-integration analysis does not show the direction of the relationship (direction of price leadership) therefore, it is important to run granger causality test which shows the nature of the relationship among the market pairs. More so, economic theory assures the presence of granger causality in at least one direction. Granger causality can either be bidirectional or unidirectional causation. In this study, 36 market links were investigated, 21 links showed bi-directional causation and 2 links showed unidirectional, while 13 links showed no causality relationship.

The analysis of the study reveals that there exist bidirectional causality between KDM and SKM and also between MHM and KDM cowpea markets price. Therefore, any increase in the price of cowpea in each of the above will lead to an increase in the price of cowpea in the other market respectively. Furthermore, unidirectional exhibited between SKM → MHM, SKM → SMG, SKM → SMKT, SKM → YNMKT, SKM → GMKT, LLMKT → SKM, KDM → MHM, GNMKT → KDM, LLMKT→ KDM, GNMKT → MHM, LLMKT → MHM, GNMKT → SKM, GNMKT → SKG, GNMKT → SMKT, LLMKT → SMKT, GNMKT → YNMKT, LLMKT → YNMKT, GNMKT → GMKT, LLMKT → GMKT and GNMKT → LLMKT. Hence, Sabon Kasuwa Mubi (SKM) and Lafiya Lamorde Market (LLMKT) occupied the leadership position in price formation and transmission. This suggest that any changes in the price of cowpea in Sabon Kasuwa Mubi (SKM) and Lafiya Lamorde Market (LLMKT) it influences the prices in the other markets in Adamawa State. This findings corroborates with that of [27] who revealed that UWB and RWB, and RBB and UWB exhibited uni-directional (one-way) causality. The implication is that there is no causality from the other markets. RBB and RWB, UWB and UBB shows bi-directional causality (two-way). This findings confirm the findings of [36, 4 and 8] who reports on various food items in Nigeria.

Table 3 Pairwise Granger causality Result

Null Hypothesis	F-Statistic	Prob.
KDM does not Granger Cause SKM	5.04266	0.0095**
SKM does not Granger Cause KDM	4.57153	0.0142**
MHM does not Granger Cause SKM	2.68329	0.0778*
SKM does not Granger Cause MHM	3.01273	0.0045**
SKM does not Granger Cause SKG	3.23387	0.0464**
SKM does not Granger Cause SMKT	2.86942	0.0025**
SKM does not Granger Cause YNMKT	4.02064	0.0001**
SKM does not Granger Cause GMKT	5.97016	0.0043**
LLMKT does not Granger Cause SKM	3.11709	0.0527*
KDM does not Granger Cause MHM	3.20496	0.0487**
GNMKT does not Granger Cause KDM	5.71115	0.0057**
LLMKT does not Granger Cause KDM	3.58814	0.0347**
MHM does not Granger Cause GMKT	2.60413	0.0836*
GNMKT does not Granger Cause MHM	5.04062	0.0100**
LLMKT does not Granger Cause MHM	2.69274	0.0771*
GNMKT does not Granger Cause SKG	5.49216	0.0069**
GNMKT does not Granger Cause SMKT	6.23823	0.0037**
LLMKT does not Granger Cause SMKT	3.27152	0.0459**
GNMKT does not Granger Cause YNMKT	6.37401	0.0033**
LLMKT does not Granger Cause YNMKT	3.41647	0.0404**
GNMKT does not Granger Cause GMKT	3.53246	0.0364**
LLMKT does not Granger Cause GMKT	3.33702	0.0433**
GNMKT does not Granger Cause LLMKT	5.05079	0.0099**

Source: Data analysis, 2022; **, * denotes rejection of null hypothesis at 5% and 10% level of significance. Note: KDM= Kasuwan Dole Mubi, SKM= Sabon Kasuwan Mubi, MHM= Maiha Market, SKG= Sabon Kasuwan Gombi, SMKT= Song Market, YNMKT= Yola North Market, GNMKT= Ganye Market, GMKT= Guyuk Market and LLMKT = Lamorde Lafiya Market.

3.4. Long run and Short run Relationship between Market Pairs

From the below Johansen co-integration test, it was found that there exist long run relationship between the market pairs. The results revealed that the coefficient price of Sabon Kasuwan Mubi was negatively significant at P< 0.05 level and less than one. This shows that there exists long run relationship running from Sabon Kasuwan Mubi to other market in the study area and also Sabon Kasuwan Mubi had a faster speed of adjustment to equilibrium, which ranged between two month (54% of price distortion restored to equilibrium within two month in Sabon Kasuwan Mubi). This study agrees with that of [8] who indicates the existence of long-term market integration between the prices of Maize and Beans in rural and urban markets of Akwa Ibom State. The Table below further shows the results of short run relationship.

The results indicated that there is short run relationship among the market pairs in the study area because the wald test of chi-square is significant as a result of free flow of market information and price signal despite the distance between the markets which accompanied by high transaction and transport costs. This study agrees with the study of [8] who reported that the producing and consuming markets have a unique short-run equilibrium in Akwa Ibom State.

Table 4 VECM of long run and short run relationship

Markets	Coefficient	Standard error	T- Statistics
SKM	-0.541882	0. 26777	2.02368**
SDM	0.995020	0.62995	1.57952
MHMM	0.803823	0.60471	1.32928
SKG	-0.888411	0.64790	1.37121
SMKT	0.795105	0.64254	1.23743
YNMKT	0.588718	0.71709	0.82099
GKMKT	0.095779	0.04816	1.98887
GNYMKT	-0.855003	0.65091	-1.31355
LLMKT	2.167799	0.81550	2.65825
Wald test result			
Test statistics	Value	P-value	
Chi-square	24.18316	0.0040**	

Source: Data analysis, 2022; ** denotes 5% level of significance

4. Conclusion and recommendations

Based on the findings of the study, it is concluded that there is a strong co-integration between cowpea markets in Adamawa as a result of the efficient free flow of price signals and market information between market pairs. Cowpea markets in the research area have a long-run and short run dynamic. The price series of cowpea between the market pairs also show signs of causality and exogeneity. As a result, the Sabon Kasuwa Mubi (SKM) and Lafiya Lamorde Market (LLMKT) are expected to drive the other markets in the study area. It is therefore, recommended that government should make market infrastructure a priority in the State by providing storage facilities and a robust transportation system. It can ensure a steady fuel price and a robust road network, as well as a favourable market environment and strong marketing surveillance through the use of effective information technology. Governments, trade unions, and other organizations should make efforts to lower the excessive externality costs connected with the sale of maize and beans in the state. This effort will help to reduce total variable costs and provide a negligible price difference between the state's bean and maize markets. To encourage efficient communication among cowpea markets in the state, the administration of Taraba State should develop market information centres and awareness initiatives on mass media (such as radio, television, and newspaper).

Compliance with ethical standards

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Disclosure of conflict of interest

There is no conflict of interest.

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