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ANALYSIS OF MARKET INTEGRATION OF NIGERIAN TOMATO MARKETS

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Abstract

Poor market integration affects market liberalization and handling of shocks such as covid-19. This study, therefore, investigates the market integration of tomato and its determinants in Nigeria. Johansen co-integration techniques, autoregressive distributed lag, the error correction model, bootstrapping regression and granger causality test were used to achieve the objectives of the study. The results revealed that most tomato markets in Nigeria were not integrated. This shows that tomato prices in most markets in different regions of Nigeria were not well integrated which could affect the transmission of price. From the Granger causality test results, ten tomato producing states Granger caused the demanding states, while only two demanding states granger caused the producing states. The adjustment term (-0.849924) shows that the reversion to long-run equilibrium is at an adjustment speed of 84.9924%. Distance, population and self-sufficiency had a negative influence on tomato market integration while the telephone had a positive influence on tomato market integration. Thus, the distance between two markets, population and self-sufficiency inhibits the flow and transmission of price information among tomato markets across the country which, in turn, lower market integration. The presence of telephone in Nigerian markets enhanced the flow of price information from one market to others and consequently increase market integration. These findings call for upgrading and investing in infrastructure, such as roads, and regulating information and telephone services by the government.

Key words*: tomato market, market integration, determinants, Nigeria, price transmission*

INTRODUCTION

Achieving efficient market integration is a veritable means to facilitate price stability, stimulate production and ensure food availability. The ability of markets to keep a stable price and make food available depends on whether markets are integrated [20]. Market integration is a condition in which commodity prices in multiple marketplaces move in lockstep, allowing for smooth price transmission [24]. It is the process through which interdependence between prices takes place and changes in commodity price in one market affect other markets. Market integration is regarded as a significant driver of price stability, food supply, accessibility and availability [5]. A responsive, integrated and efficient market mechanism is vital to maximizing the resource area in agriculture and encouraging farmers to increase their production [5].

Across African countries, most agricultural markets are inefficient and not well integrated, particularly in Nigeria, the performance of agricultural marketing is weak [2, 21, 22]. Poor marketing system and function lead to several setbacks in agricultural production, causes price fluctuation and forced farmers to sell at any available price due to the perishable nature of the agricultural products which posed them to risk [18]. Thus, integration of agricultural markets is important in developing nations, which mostly relied on primary goods from the agricultural sector for the smooth running of their economy. Achieving market integration and price stability is very critical for vegetable crops because of their perishable nature and the need to have an efficient marketing system to reduce wastage. This is particularly important for tomato in which about 45% of fresh tomato produced annually was lost in 2017 [26]. In fact, a significant

portion of the income of tomato farmers in Nigeria has been lost due to wastage [23].

Poor market integration poses a threat to the agricultural marketing system in Nigeria. For instance, poor tomato market integration is affecting market liberalization and handling of shocks such as flood and COVID-19. An inefficient agricultural marketing system limits agricultural expansion [8]. It also results in poor price transmission and fluctuation in tomato prices. The poor marketing system of tomato increases the extent of post-harvest loss and further spoilage of the crop due to its perishable nature which requires an immediate and efficient agricultural marketing system. This is evidenced as Abimbola [1] found that the gross margin of tomato farmers decreased from 80% to 17% due to post-harvest losses.

There is a need to improve the tomato marketing system, which plays a significant role in households in developing nations, to ensure market integration and stability in tomato price to improve the wellbeing of both producers and marketers in Nigeria. If tomato price is synchronized across Nigeria, it will boost production by encouraging farmers to produce at a large scale all year round. This will further ensure that supply meets up with demand and tomato spoilage will be reduced.

Given the importance of tomato crop and the effect of market integration in stimulating production, efficient marketing and income to farmers, and also to facilitate government policy interventions, there is a need to understand the extent and causes of tomato market integration.

Previous studies on integration of agricultural commodities markets concentrated on cereal, roots and tuber crops [3, 11, 12, 15, 20, 24, 25, 29]. While vegetable crops such as tomato which provide income to many households, serve as means of livelihood in developing nations received less attention, especially in the area of market integration. The available studies [6, 27, 28] only investigate the level of tomato market integration without identifying the factors responsible for the degree of tomato market integration. The studies by Shrestha *et al.* [28] and Baiyegunhi *et al*. [6] covered a few markets and were not conducted in Nigeria. In addition, Baiyegunhi *et al.* [6] used the Augmented Engle-Granger test to test for cointegration in the markets. However, the Augmented Engle-Granger test was considered inferior to the Johansen cointegration test which was adopted in this study. This is because the Johansen cointegration test does not assume apriori that a single vector for co-integration exists but rather measures the number of vectors for co-integration [4]. The present study intended to add to existing literature and fill the gap by identifying the factors inhibiting or enhancing the tomato market integration in Nigeria.

Therefore, this study was poised to examine the market integration of tomato markets in Nigeria. Specifically, the study determines the extent of market integration between different spatial tomato markets; examine the direction of causality of price between the supply and demand states; measure the speed of tomato price adjustment process to the long-term multipliers; and identify the factors which inhibit or enhance tomato market integration in Nigeria.

MATERIALS AND METHODS

The study area is Nigeria. The country has a total land area of 923,768 km^2. Nigeria is an agrarian nation endowed with rich natural resources, suitable weather conditions for agricultural production [17]. Agriculture contributes greatly to Nigeria economy and employs about 70 per cent of the workforce [19]. One of the major vegetable crops produced in Nigeria is tomato [3]. Nigeria is the largest tomato producer in sub-Sahara Africa, 2nd in Africa and 11th in the world, [10]. Tomatoes are mostly farmed in the northern portion of the country and are widely distributed throughout the country. To have a good representation and considering the fact that tomato is marketed and consumed across the country, all the six geopolitical zones in Nigeria were used for this study. Twelve states and the Federal Capital Territory, Abuja, were used for the study.

Secondary data was used in this investigation. Data on monthly tomato price per kilogram in various states from 2016 to 2020 were

sourced from the National Bureau of Statistics (NBS). This was long enough to measure the market integration as it gives sixty data points or observations. This is, however, considered a large sample and acceptable to conduct research on market integration [6]. Data on other variables were also sourced from NBS.

Data Analysis Techniques

The data for this study were analysed with Augmented Dickey-Fuller model, Johansen co-integration techniques, bivariate Granger causality test, the error correction model (ECM) and the bootstrapping regression model.

Augmented Dickey-Fuller (ADF) Model

Before proceeding with analysing any time series data there is a need to check for the stationarity level of the series to adopt the appropriate model in a view to avoid spurious regression [16]. This would allow understanding the behaviour, nature and order of integration of the series [16]. To test for the unit root properties of the variables ADF test was employed.

This is specified as:

$$\Delta\gamma_t = X_t\,\beta + \delta\gamma_{t-1} + \alpha_i \sum_{i=1}^{p} \Delta\gamma_{t-i} + \varepsilon_t$$

.....(1)

where:

Δ = difference operator

γ_t = vector of the n variables (the price of tomatoes from different markets)

X_t= are optional exogenous regressors

β= coefficients

$\sum$ = summation

ρ = number of lags

ε_t= error term

Johansen Cointegration Test

In examining the market integration, the Johansen cointegration test has gained wide recognition and usage. The Johansen Cointegration test was used in this study to examine if tomato markets in spatial locations are integrated. It was, however, used for variables with the same integration order. It is specified as:

$$\Delta У_t = \Pi У_{t-1} + \sum_{t=1}^{p-1} \Gamma_i\,\Delta У_{t-i} + Bx_t + \mathcal{E}_t$$

.....(2)

where:

$\Delta У_t$= first difference of an (*n* x *i*) vector of the *n* variables of interest (tomato price).

Π= (*n* x *n*) Coefficient matrix associated with lagged values of the endogenous dependent variable, which has a reduced rank of r<k.

$\Pi У_{t-1}$= lagged values of Y_t

Γ = Matrix of short-term coefficients (n x (k – 1))

Bx_t = Cointegrating vector (n x 1)

$\mathcal{E}_t$ = Vector of white noise residuals (n x 1)

Both the maximum-eigenvalue and trace test statistics from the Johansen cointegration test will be employed.

Autoregressive Distributed Lag (ARDL) Bound Test

The ARDL bound test was used to examine if tomato markets in spatial locations are integrated among variables of a different order of integration. it is specified as:

$$\Delta M_{it} = \alpha_1 + \sum_{i=1}^{p} \beta_i\,\Delta M_{i(t-1)} + \sum_{i=1}^{p} \gamma_i\,\Delta M_{j(t-1)} + \varepsilon_{1t}$$

$$\Delta M_{jt} = \alpha_2 + \sum_{i=1}^{p} \pi_i\,\Delta M_{i(t-1)} + \sum_{i=1}^{p} \rho_i\,\Delta M_{j(t-1)} + \varepsilon_{2t}$$

.....(3)

where:

Δ= difference operator which denotes a k x 1 vector of cointegrated variables (tomato prices in different markets) of order 1.

$M_{i(t-1)}$ = lagged tomato price in the market i.

$M_{j(t-1)}$ = lagged tomato price in market j.

M_{t-1} = lagged tomato price in different markets.

$\varepsilon_{1t}$and ε_{2t} =Error term

Granger Causality Test

Granger causality test proposed by Granger in 1969 is used to examine the causal relationships and direction of causality between variables [16]. To explore the causality between the price of tomatoes in the market *i* and market *j*, the bivariate Granger casualty test was used. Here, the average price of tomato in the major tomato producing states and the average price in low producing states were used. This is to identify the direction of causality among the supply and demand states. The major producing states

were used as the supply states while low producing states were used as demand states. The Granger casualty between the price of tomato in spatially located markets (demand and supply states) is specified as:

$$\Delta lnPR_t = \alpha_1 + \sum_{i=1}^{n} \beta_i \, \Delta lnPR_{t-i} + \sum_{i=1}^{m} \delta_j \, \Delta lnPU_{t-j} + r_1(EC_1)_{t-1} + \varepsilon_t$$

$$\Delta lnPU_t = \alpha_2 + \sum_{i=1}^{n} c_i \, \Delta lnPU_{t-i} + \sum_{i=1}^{m} g_j \, \Delta lnPR_{t-j} + r_2(EC_2)_{t-1} + \mu_t \quad \text{.....(4)}$$

where:

Δ = first difference operator

PR_t = monthly tomato price in the supply market (major producing state)

PU_t = monthly tomato price in the demanding state (low producing state)

ln = natural logarithm transformation

α_1 and α_2 = intercept

β_i, δ_i, g_i, and c_i = coefficient

ε_t and μ_t = error term

n and *m* = numbers of lag lengths

$(EC_1)_{t-1}$ and $(EC_2)_{t-1}$ = error correction terms.

If δ_j is significant but g_j is not, it means that a unidirectional causality exists from the supply market (major producing states) to demand markets (low producing states). Conversely, if only g_j is significant, a unidirectional causality exists from demand market to supply markets. If both δ_j and g_j are significant, there is a bidirectional causality implying that supply markets Granger cause demand markets and vice versa. If both coefficients are not significant, there is no causality running from any of the markets to the other.

Error Correction Model

The ECM was used in measuring the speed of price transmission and adjustment to long-run multiplier or equilibrium. It is specified as:

$$\Delta M_{it} = \alpha_1 + \sum_{i=1}^{p} \beta_i \, \Delta M_{i(t-1)} + \sum_{i=1}^{p} \gamma_i \, \Delta M_{j(t-1)} + \varphi_1 \mu_{t-i} + \varepsilon_{1t}$$

$$\Delta M_{jt} = \alpha_2 + \sum_{i=1}^{p} \pi_i \, \Delta M_{i(t-1)} + \sum_{i=1}^{p} \rho_i \, \Delta M_{j(t-1)} + \varphi_2 \mu_{t-i} + \varepsilon_{2t} \quad \text{.....(5)}$$

where:

Δ= difference operator which denotes a k x 1 vector of cointegrated variables (tomato prices in different markets) of order 1.

$M_{i(t-1)}$ = lagged tomato price in the market i.

$M_{j(t-1)}$ = lagged tomato price in market j.

M_{t-1} = lagged tomato price in different markets.

μ_{t-i} = error correction term.

$\varphi_i$and φ_j= adjustment speed.

$\varepsilon_{1t}$and ε_{2t} =Error term

Bootstrapped Regression Model

To identify the determinants of tomato market integration, the trace statistics result from the Johansen cointegration analysis for each possible pair of the markets were regressed against some explanatory variables. Considering the fact that the cointegration test statistics which was used as regressand was generated and follows a non-normal (non-standard) distribution. The ordinary least square (OLS) cannot be directly used because the OLS estimator is not normally distributed [13, 14]. To deal with the violations of normality (by OLS) and derive useful parameter estimates, bootstrapping which is a distribution-free method introduced by Efron [9] and used by Goodwin and Schroeder [13] and Ismet et al. [14] was adopted in this study to identify the determinants of tomato market integration. It is specified as:

$$TMI = \beta_0 + \beta_1 Trancost_{1i} + \beta_2 Tele_{2i} + \beta_3 Dist_{3i} + \beta_4 Cont_{4i} + \beta_5 Pop_{5i} + \beta_6 Self_{6i} + \varepsilon_i \quad \text{.....(6)}$$

where:

TMI is the tomato market integration

Trancost is the transportation cost. This measures the level of infrastructural facilities such as a good road network, a low transport suggests a good transportation network while a high transportation cost suggests a poor transportation network.

Tele is the telephone density. It is a proxy for the availability of information.

Dist is the distance from one market (state) to the other.

Cont is the contiguity (1 if the state shares a border, 0 if not). This will measure the additional costs involved in tomato marketing cost.

Pop is the population (number of people living in the state).
Self is self-sufficient in tomato (1 if a major tomato producer, 0 otherwise). This measures the level of tomato production in terms of meeting the state demands.
β_0= constant
ε_i = Stochastic error term

RESULTS AND DISCUSSIONS

The unit root property of tomato prices across spatially separated markets in Nigeria were presented in Table 1. The results revealed that tomato prices in Bauchi, Benue, Sokoto, Kaduna, Lagos and Ondo states were not stationary in the level form. They, however, became stationary after the first difference. This means that the variables are order one. While tomato prices in Taraba, Plateau, Enugu, Anambra, Rivers, Cross River states and Abuja (FCT) were stationary at level form. This implies that these variables are order zero.

Table 1. Unit root property of tomato price

Variables	Level	First Difference
Bauchi	-0.803226 (0.8093)	-5.85478 (0.0000)
Taraba	-2.765427 (0.0695)	8.2863 (0.0000)
Benue	-2.549004 (0.1094)	-7.81098 (0.0000)
Plateau	-2.876504 (0.0542)	-7.865429 (0.0000)
Sokoto	-1.77882 (0.3873)	-8.930966 (0.0000)
Kaduna	-1.61370 (0.4692)	-11.8404 (0.0000)
Lagos	-2.28944 (0.1787)	-10.29302 (0.0000)
Ondo	-2.5269 (0.1144)	-7.52985 (0.0000)
Enugu	-4.8996 (0.0002)	-6.4889 (0.0000)
Anambra	-3.50798 (0.0111)	-7.128149 (0.0000)
Rivers	-2.72809 (0.0754)	-9.45669 (0.0000)
Cross River	-3.61088 (0.0084)	-6.72578 (0.0000)
Abuja	-3.13119 (0.0268)	-9.30195 (0.0000)

Note: *, ** and *** denote rejection of the null hypothesis at 10%, 5% and 1% significant levels respectively based on the Mackinnon critical values. P-values of test statistics are in parenthesis.
Source: Data analysis, 2021.

The extent of market integration between different spatial tomato markets in Nigeria

To examine the tomato market integration in different markets across the country, the Johansen cointegration and bound test of the ARDL were used based on the stationary level of tomato prices (variables) in different states. Table 2 presents the result of Johansen cointegration used for variables of the same order. The Maximal eigenvalue test and the Trace test were both employed to determine whether or not the markets were integrated. If the Maximal eigenvalue test and Trace test statistic were more than the 5% threshold criterion, it indicates integrated markets. Tomato marketplaces in Northwest Nigeria were found to be integrated, according to the findings. This implies that tomato prices in northwest Nigeria will effectively be transmitted within the region and any policy implemented in any part of the region will easily be transmitted across the region (northwest Nigeria). This is because market integration information offers specific evidence of market competition, arbitrage efficacy and pricing efficiency [7]. The markets in Northwest and southwest were integrated. This implies that tomato prices were effectively transmitted between the two regions. Thus, price change in the northwest will affect tomato prices in the southwest. In southwest Nigeria, the tomato markets were not integrated. This means that pricing information and movement within tomato markets in southwest Nigeria is not well transmitted. This is because unintegrated markets will communicate wrong price information that could distort marketing decisions by producers and lead to inefficient product movements [13].

The tomato markets in southeast Nigeria were integrated. This means that tomato prices in southeast Nigeria move in lockstep, and price information and signals are easily communicated through markets. Also, tomato markets in south-south and Southeast were integrated. This means that variations in tomato prices in the southeast and south-south were easily transferred, and that changes in tomato prices in either zone would affect the other. In the south-south, tomato markets were merged. This implies that tomato prices within the zone were well transmitted from one market to the other. Thus, a change in price in one state within the south-south region will cause a change in another market within the zone.

Table 2. Tomato market integration across Nigeria (Johansen cointegration results)

Markets		Trace test		Maximal eigenvalue test	
		Statistic	5% C.V.	Statistic	5% C.V.
North west	None	20.37578**	15.49471	14.11304	14.26460
	At most 1	6.262740**	3.841465	6.262740**	3.841465
North west and south west	None	62.55476**	47.85613	35.40631**	27.58434
	At most 1	27.14844	29.79707	14.91918	21.13162
	At most 2	12.22926	15.49471	10.88151	14.26460
	At most 3	1.347754	3.841465	1.347754	3.841465
South west	None	10.64717	15.49471	9.360369	14.26460
	At most 1	1.286799	3.841465	1.286799	3.841465
South east	None	28.21408**	15.49471	20.63318**	14.26460
	At most 1	7.580898**	3.841465	7.580898**	3.841465
South east and south-south	None	70.80281**	47.85613	33.74730**	27.58434
	At most 1	37.05551**	29.79707	17.43129**	21.13162
	At most 2	19.62422**	15.49471	10.11935**	14.26460
	At most 3	9.504867**	3.841465	9.504867**	3.841465
South-south	None	17.43640**	15.49471	12.08200	14.26460
	At most 1	5.354401**	3.841465	5.354401**	3.841465

Source: Data analysis, 2021.

The results of the ARDL Bound test used for variables (tomato price) of different orders were presented in Table 3. The results revealed that tomato markets in northeast Nigeria were integrated as indicated by F-statistics (11.96239) which was greater than the upper and lower limits at all significant levels. This implies that tomato prices in the Northeast market were well transmitted and change in any market will result in a change in other markets. Meanwhile, the tomato markets in northeast and Northcentral were not integrated as evidenced by the F-statistics (1.004137) which was lower than the lower limits at all significant levels. This implies that tomato prices in the markets within the northeast and northcentral were not well transmitted. Goodwin and Schroeder [13] stated that unintegrated markets will communicate wrong price information that could distort marketing decisions by producers and lead to inefficient product movements. Thus, a change in tomato price in the northeast will not affect tomato price in the northcentral, and vice versa. Tomato markets in northeast and Northwest were integrated as indicated by F-statistics (9.048741) which was greater than the upper and lower limits at all significant levels. This implies that tomato prices in the northeast and northwest move together and price signals are easily transmitted. In addition, the northeast and southwest tomato markets were integrated. This means that signals and information on tomato prices may easily be transferred between marketplaces in the northeast and southwest. The tomato markets in the Northeast and southeast were integrated. This implies that tomato prices in the northeast and southeast were well transmitted among the markets. The tomato markets in northeast and south-south were integrated. This implies that tomato price

information and signal in the northeast and south-south were well transmitted.

The tomato markets in northcentral were not integrated as indicated by F-statistics (1.537946) which was lesser than the upper and lower bound limits at all significant levels. This result implies that tomato price signals and information in northcentral markets were not well transmitted. In the same vein, tomato markets in the northcentral and northwest were not integrated. This also implies that tomato price information and signals in northcentral and Northwest markets were not well transmitted. Thus, changes in tomato markets in any of the markets in the two zones did not effectively affect tomato prices in other markets.

Table 3. Tomato market integration across Nigeria (Bound test results)

	Test statistic	Value	Sig. level	I(0)	I(1)
North east	F-Statistics	11.96239	10%	3.02	3.51
	K	1	5%	3.62	4.16
			2.5%	4.18	4.79
			1%	4.94	5.58
North east and North central	F-Statistics	1.004137	10%	2.2	3.09
	K	4	5%	2.56	3.49
			2.5%	2.88	3.87
			1%	3.29	4.37
North east and North west	F-Statistics	9.048741	10%	2.37	3.2
	K	3	5%	2.79	3.67
			2.5%	3.15	4.08
			1%	3.65	4.66
North east and south west	F-Statistics	6.687093	10%	2.37	3.2
	K	3	5%	2.79	3.67
			2.5%	3.15	4.08
			1%	3.65	4.66
North east and south east	F-Statistics	6.907528	10%	2.37	3.2
	K	3	5%	2.79	3.67
			2.5%	3.15	4.08
			1%	3.65	4.66
North east and south-south	F-Statistics	7.574823	10%	2.37	3.2
	K	3	5%	2.79	3.67
			2.5%	3.15	4.08
			1%	3.65	4.66
North central	F-Statistics	1.537946	10%	2.63	3.35
	K	2	5%	3.1	3.87
			2.5%	3.55	4.38
			1%	4.13	5
North central and north west	F-Statistics	2.973333	10%	2.2	3.09
	K	4	5%	2.56	3.49
			2.5%	2.88	3.87
			1%	3.29	4.37
North central and south west	F-Statistics	5.088846	10%	2.2	3.09
	K	4	5%	2.56	3.49
			2.5%	2.88	3.87
			1%	3.29	4.37
North central and south east	F-Statistics	1.220422	10%	2.2	3.09
	K	4	5%	2.56	3.49
			2.5%	2.88	3.87
			1%	3.29	4.37
North central and south-south	F-Statistics	1.148590	10%	2.2	3.09
	K	4	5%	2.56	3.49
			2.5%	2.88	3.87
			1%	3.29	4.37

Source: Data analysis, 2021.

The tomato markets in North Central and southwest were integrated as indicated by F-statistics (5.088846) which was greater than the upper and lower limits at all significant levels. This implies that tomato price information and signal in northcentral and southwest were well transmitted and any change in tomato price within the two zones will affect other markets in the same zones. The tomato markets in the northcentral and southeast were not integrated as indicated by F-statistics (1.220422) which was lesser than the upper and lower bound limits at all significant levels. This implies that tomato price information and signal were not well transmitted among markets between north-central and southeast. The tomato markets in northcentral and south-south were also not integrated as indicated by F-statistics (1.148590) which was lesser than the upper and lower bound limits at all significant levels. This implies that tomato markets information and signal were not well transmitted between northcentral and south-south tomato markets. The tomato market in the Northwest and southeast were not integrated as indicated by F-statistics (2.134382) which was lesser than the upper and lower bound limits at all significant levels. This also implies that changes in tomato prices were not well transmitted between the tomato market in the Northwest and the Southeast.

Table 4. Tomato market integration across Nigeria (Bound test results) continued

	Test statistic	Value	Sig. level	I(0)	I(1)
North west and south east	F-Statistics	2.134382	10%	2.37	3.2
	K	3	5%	2.79	3.67
			2.5%	3.15	4.08
			1%	3.65	4.66
North west and south-south	F-Statistics	1.628250	10%	2.37	3.2
	K	3	5%	2.79	3.67
			2.5%	3.15	4.08
			1%	3.65	4.66
South west and south east	F-Statistics	2.241119	10%	2.37	3.2
	K	3	5%	2.79	3.67
			2.5%	3.15	4.08
			1%	3.65	4.66
South west and south-south	F-Statistics	1.209207	10%	2.37	3.2
	K	3	5%	2.79	3.67
			2.5%	3.15	4.08
			1%	3.65	4.66
North west	F-Statistics	1.665857	10%	3.02	3.51
	K	1	5%	3.62	4.16
			2.5%	4.18	4.79
			1%	4.94	5.58
North east, North central and north west (supply side)	F-Statistics	6.290346	10%	2.08	3
	K	5	5%	2.39	3.38
			2.5%	2.7	3.73
			1%	3.06	4.15
South west, south east, south-south and FCT (demand side)	F-Statistics	1.656574	10%	1.99	3.153
	K	6	5%	2.27	3.28
			2.5%	2.55	3.61
			1%	2.88	3.99

Source: Data analysis, 2021.

The Northwest and South-South tomato markets were not connected. As a result, tomato prices in the Northwest and South-South were not properly communicated. Furthermore, tomato markets in the geopolitical zones of the Southwest and Southeast were not linked. This suggests that tomato prices in the Northwest and South-South marketplaces were not effectively communicated. The Southwest and South-South tomato markets were not integrated. This indicates that tomato prices were not adequately communicated between the southwest and the south-south. In the

northwest, the tomato markets were likewise not integrated. This suggests that the signal and information on tomato pricing in northwest markets were not properly integrated. The tomato markets in the supply states (Northeast, Northcentral and northwest) were integrated. This result implies that tomato price signal and information were well transmitted among markets in the tomato supply states. Changes in the price of tomato in one state were well transmitted to other tomato supply states. This could be because the tomato supply states share the same features such as variable climatic conditions and had a similar cost of production. The tomato markets in the demand states (Southwest, Southeast and south-south) were not integrated as indicated by F-statistics (1.656574) which was less than the upper and lower limits at all significant levels. This result implies that tomato price signals and information were not well transmitted among markets in the tomato demanding states.

The direction of tomato price causality between supply and demand states

From the granger causality test results presented in Table 5, ten tomato producing states granger caused the demanding states, while only two demanding states granger caused the producing states. Tomato price in Bauchi state granger causes tomato price in Anambra state. Tomato prices in Bauchi states also granger caused tomato prices in Cross River states. In the same vein, tomato prices in Taraba state granger caused tomato prices in Ondo state. Tomato price in Taraba state granger causes tomato price in Abuja. Tomato prices in Plateau state also granger cause tomato prices in Abuja markets. Furthermore, tomato prices in Sokoto state granger caused tomato prices in Lagos state. Also, tomato prices in Sokoto state granger caused tomato prices in River state. The result further shows that tomato prices in Kaduna state granger caused tomato prices in Enugu state. Tomato prices in Kaduna state also granger caused tomato prices in Anambra state. In addition, tomato prices in Kaduna state granger caused tomato prices in River state. While tomato price in Abuja granger caused tomato price in Benue state and tomato price in River state granger cause tomato price in Sokoto states. These results imply that tomato price in the producing states determine the tomato price in demanding states and the previous price of tomato in the producing states can be used to predict the current price of tomato in the demanding states. This could be because tomato marketers who got the tomato from the producing states will tag a price to it based on the amount sold in the producing states.

In addition, the result revealed that only tomato markets in Sokoto state and Rivers State shows a two-way Granger causality while the majority of the tomato markets did not show a two-way Granger causality.

Table 5. The direction of causality of tomato price between the supply and demand states

	Statistics	Probability	Decision
Lagos price DNGC Bauchi	1.99487	0.1461	A
Bauchi price DNGC Lagos	1.42010	0.2507	A
Ondo price DNGC Bauchi	0.94480	0.3952	A
Bauchi price DNGC Ondo	0.06860	0.9338	A
Enugu price DNGC Bauchi	1.94047	0.1537	A
Bauchi price DNGC Enugu	0.17708	0.8382	A
Anambra price DNGC Bauchi	0.61873	0.5425	A
Bauchi price DNGC Anambra	3.45477	0.0389	R
Cross River price DNGC Bauchi	0.30625	0.7375	A
Bauchi price DNGC Cross River	10.6279	0.0001	R
River price DNGC Bauchi	1.35842	0.2659	A
Bauchi price DNGC River	0.53302	0.5899	A
Abuja price DNGC Bauchi	0.09934	0.9056	A
Bauchi price DNGC Abuja	0.55502	0.5774	A
Lagos price DNGC Taraba	2.19234	0.1217	A
Taraba price DNGC Lagos	1.96075	0.1508	A
Ondo price DNGC Taraba	0.12759	0.8805	A
Taraba price DNGC Ondo	7.78647	0.0011	R
Enugu price DNGC Taraba	0.41423	0.6630	A
Taraba price DNGC Enugu	0.70649	0.4980	A

Anambra price DNGC Taraba	0.21904	0.8040	A
Taraba price DNGC Anambra	1.14515	0.3259	A
Cross River price DNGC Taraba	0.10983	0.8962	A
Taraba price DNGC Cross River	0.40445	0.3259	A
Rivers price DNGC Taraba	1.03990	0.3606	A
Taraba price DNGC Rivers	1.05724	0.3546	A
Abuja price DNGC Taraba	0.67068	0.5156	A
Taraba price DNGC Abuja	3.57293	0.0350	R
NB: DNGC = Does not Granger cause, A = Accept, and R = Reject			
Ondo price DNGC Benue	0.74041	0.4818	A
Benue price DNGC Ondo	0.15291	0.8586	A
Enugu price DNGC Benue	0.66252	0.5198	A
Benue price DNGC Enugu	1.25578	0.2932	A
Anambra price DNGC Benue	0.14536	0.8651	A
Benue price DNGC Anambra	0.81358	0.4487	A
Cross River price DNGC Benue	1.03565	0.3621	A
Benue price DNGC Cross River	0.47648	0.6236	A
River price DNGC Benue	0.17117	0.8431	A
Benue price DNGC River	1.48165	0.2365	A
Abuja price DNGC Benue	3.78474	0.0291	R
Benue price DNGC Abuja	0.66206	0.5200	A
Lagos price DNGC Plateau	1.02930	0.3643	A
Plateau price DNGC Lagos	0.11398	0.8925	A
Ondo price DNGC Plateau	0.15275	0.8587	A
Plateau price DNGC Ondo	1.99447	0.1462	A
Enugu price DNGC Plateau	0.03655	0.9641	A
Plateau price DNGC Enugu	1.04619	0.3584	A
Anambra price DNGC Plateau	0.30929	0.7353	A
Plateau price DNGC Anambra	1.09622	0.3416	A
Cross River price DNGC Plateau	2.29880	0.1103	A
Plateau price DNGC Cross River	0.18687	0.8301	A
Abuja price DNGC Benue	3.78474	0.0291	R
Benue price DNGC Abuja	0.66206	0.5200	A
River price DNGC Plateau	0.22534	0.7990	A
Plateau price DNGC River	0.82969	0.4418	A
Abuja price DNGC Plateau	1.08548	0.3451	A
Plateau price DNGC Abuja	4.36411	0.0178	R
Lagos price DNGC Sokoto	1.97272	0.1492	A
Sokoto price DNGC Lagos	3.64272	0.0329	R
Ondo price DNGC Sokoto	0.39361	0.6766	A
Sokoto price DNGC Ondo	0.01717	0.9830	A
Enugu price DNGC Sokoto	0.59240	0.5566	A
Sokoto price DNGC Enugu	0.83729	0.4385	A
Anambra price DNGC Sokoto	1.50715	0.2309	A
Sokoto price DNGC Anambra	0.67372	0.5141	A
Cross River price DNGC Sokoto	0.14865	0.8622	A
Sokoto price DNGC Cross River	0.28052	0.7565	A
River price DNGC Sokoto	2.63383	0.0812	R
Sokoto price DNGC River	5.52711	0.0066	R
Abuja price DNGC Sokoto	0.09221	0.9121	A
Sokoto price DNGC Abuja	1.52423	0.2272	A
Lagos price DNGC Kaduna	2.35674	0.1046	A
Kaduna price DNGC Lagos	0.31649	0.7301	A
Ondo price DNGC Kaduna	0.61039	0.5469	A
Kaduna price DNGC Ondo	0.04444	0.9566	A
Enugu price DNGC Kaduna	1.03683	0.3617	A
Kaduna price DNGC Enugu	3.19326	0.0490	R
Anambra price DNGC Kaduna	1.99144	0.1466	A
Kaduna price DNGC Anambra	4.02126	0.0237	R
Cross River price DNGC Kaduna	1.31674	0.2766	A
Kaduna price DNGC Cross River	1.42605	0.2493	A
River price DNGC Kaduna	0.82064	0.4457	A
Kaduna price DNGC River	2.86159	0.0660	R
Abuja price DNGC Kaduna	0.02063	0.9796	A
Kaduna price DNGC Abuja	0.08509	0.9186	A

NB: DNGC = Does not Granger cause, A = Accept, and R = Reject
Source: Data analysis, 2021.

The speed of the tomato price adjustment process to the long-term multipliers

As shown in Table 6, the error correction coefficient (CointEq(-1)) was negative and significant, which is a favourable sign. The ECM results were accurate and in line with expectations. The ECM results appeared within the expectation and had correct signs. The adjustment term (-0.849924) shows that the reversion to long-run equilibrium is at an adjustment speed of 84.9924%. This implies that 84.9924% of disequilibrium error in tomato price was corrected within a year and tomato price returns to its equilibrium level in about a year in absence of any other shocks.

Table 6. The speed of tomato price adjustment process to the long-term multipliers

	Coefficient	Standard error	t-statistics	Prob.
CointEq(-1)*	-0.849924	0.081659	-10.40819	0.0000
R-square	0.746280			
Adjusted R-square	0.722344			
S.E. of regression	22.707060			
Log-likelihood	-264.7929			
Durbin-Watson stat	2.255069			
Akaike info criterion	9.179421			
Schwarz info criterion	9.390696			
Hannan-Quinn criterion	9.261894			

Source: Data analysis, 2021.

Factors influencing tomato market integration in Nigeria

Table 7 presents the factors influencing tomato market integration in Nigeria. The result revealed that distance, population, self-sufficiency and telephone had a significant influence on tomato market integration in Nigeria. The coefficient of distance had a negative influence on tomato market integration in Nigeria. This implies that the longer the distance cover from a spatial market to another, the lower the market integration. Thus, distance cover reduces tomato market integration. This is because commodity price is well transmitted when the distance between two markets is short. A longer distance also increases transportation costs which reduces market integration. A similar result was reported by Goodwin and Schroeder [13] that distance deters cattle markets integration in the US. This is also in tandem with Goletti et al. [12] who reported that distance from one market to another influenced rice market integration in Bangladesh.

The population had a negative effect on tomato market integration in Nigeria. This implies that an increase in population in a particular location reduces the tomato market integration. This could be because a tomato producing state with a high population could have enough demand for the product from the state which will lower the moving of the product to other markets in other zones or states and consequently lower price transmission and signals.

Self-sufficiency in tomato production had a negative effect on tomato market integration in Nigeria. This implies that being self-sufficient in tomato production reduces the tomato market integration. This could be because a self-sufficient state can decide the price to sell tomato without necessarily considering the price in other states.

The telephone density had a positive influence on tomato market integration. This implies that the presence of the telephone in Nigerian markets increases the tomato market integration. This is because the telephone enhances the transmission of tomato prices among spatially separated markets. Farmers and marketers can easily ask the price of tomato in other markets via the telephone. This supports the findings of Goletti et al. [12] who reported that telephone density had a positive influence on rice market integration in Bangladesh.

Table 7. Factors influencing tomato market integration in Nigeria

Variables	Coefficient	Standard error	t-statistics	Prob.
Contiguity	-3.424172	1.845185	-1.855734	0.1226
Distance	-0.010891***	0.001566	-6.952738	0.0009
Population	-2.88E-06*	1.15E-06	-2.507132	0.0540
Self sufficiency	-11.88839***	2.137022	-5.563065	0.0026
Telephone	1.38E-06*	6.33E-07	2.180264	0.0811
Transportation cost	-0.024180	0.014439	-1.674632	0.1549
Constant	64.51281	9.395746	6.866173	0.0010
R-square	0.906186			
Adjusted r-square	0.793608			
F-statistics	7.452			
Probability	0.014			

Source: Data analysis, 2021.

CONCLUSIONS

This study analysed the market integration of tomato in Nigeria. Market integration appears to be limited in tomato markets in different regions of Nigeria. Meanwhile, the combination of tomato markets in the supply states (Northeast, Northcentral and northwest) were integrated. Thus, tomato price information and signals were well transmitted among markets in the tomato supply states. The combination of tomato markets in the demand states (Southwest, Southeast and south-south) were not integrated which implies that tomato price information and signals were not well transmitted among markets in the tomato demanding states. The tomato price in the producing states determines the tomato price in demanding states and the previous price of tomato in the producing states can be used to predict the current price of tomato in the demanding states. About 85% of disequilibrium error in tomato price was corrected within a year and tomato price returns to its equilibrium level in about a year in absence of any other shocks. Distance contributed immensely to tomato market integration, the longer the distance the lower the market integration. while telephone enhanced the market integration as it assists to transmit price across regional tomato markets in Nigeria.

The study recommends upgrading and investing in infrastructure such as roads would also enhance tomato market integration. A good road network is equivalent to a shorter distance between spatially separated markets which will reduce time to transmit tomato price information and reduce transaction cost. This would ensure adequate movement of tomato from the surplus or supplying states to the shortage or demanding states. This can be achieved by improving the existing roads and constructing new ones. There is also a need to encourage tomato market price information in Nigeria to enhance market integration and reduce price differences. Information flow about prices, demand and supply of tomato will enhance market integration as it will increase the speed of price transmission. Government can formulate policies that will regulate information services and tomato prices to avoid market exploitation. Provision of tomato price information centre, where tomato daily prices will be disseminated, by the government will also enhance the flow of price information and communication within spatially different markets. The provision of efficient telecommunication networks in the rural areas would also enhance the price transmission of tomatoes in Nigeria.

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