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Agricultural price transmission across space and time: The case of cowpea and yam markets in Nigeria

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ABSTRACT

The transmission of price changes to markets has attracted renewed interest since the international food price spikes of 2007 to 2011. In response to this, this paper investigates the long-run behaviour of Nigerian cowpeas and yam tuber retail prices across space and time from 2000 to 2015. We employed the augmented Dickey-Fuller unit root test, the Johansen co-integration test, the Granger causality test, the vector error-correction model (VECM) and variance decomposition analysis. The Johansen co-integration test confirmed the presence of a long-run relationship across the markets, while the VECM revealed that the speed of adjustment to equilibrium after price shocks in the yam and cowpea markets varied across space (market) and period (time), with the food crisis in the period pre-2007 to 2011 fastest and the food crisis in the period 2007 to 2011 slowest. We are of the opinion that the presence of a long-run relationship in Nigerian cowpea and yam markets is a call for participants to explore opportunities for gainful trade.

Key words: price; transmission; Nigeria; space; time

1. Introduction

The agricultural sector plays an indispensable role in ensuring food security and availability. After the international food price spikes of 2007/2008 and 2010/2011, price development and transmission in the agri-food sector became the subject of many studies. This is because food price instability aggravates food security, particularly in developing countries like Nigeria (FAO 2008; Von Cramon-Taubadel 2014).

Akpan *et al*. (2014) observed that price instability among agricultural commodities is a regular phenomenon in markets across Nigeria. This instability in commodity market prices in parts of Nigeria has been attributed to possible inefficiencies in the food distribution system and to market imperfections, and the attainment of efficient market performance is determined by the extent to which price signals are transmitted across markets. Akpan and Udoh (2007) have warned that variations in commodity prices among markets could be detrimental to the marketing system, and to the economy as a whole, because it could cause inefficiency in resource allocation among sellers and consumers, and could also increase poverty levels among the low-income earners in society. Also, the ability of markets to make food available and to keep prices stable depends on whether markets are integrated with each other. Integrated markets are markets in which prices for comparable goods do not behave independently, hence price changes in one location are consistently related to price

changes in other locations and market agents are able to interact between different markets (Nigerian Institute of Social and Economic Research [NISER] 2008; Akinseye 2011).

Crops grown in Nigeria include root and tuber crops like cassava, yam, cocoyam and sweet potato; grains and cereals like sorghum, millet, rice and maize; and pulses and legumes like beans, groundnut and melon (Famine Early Warning Systems Network [FEWSNET] 2008; Phillips *et al*. 2013). Food legumes play an important and diverse role in the farming systems and diets of poor people around the world. They are ideal crops for reducing poverty, improving human health and nutrition, and enhancing ecosystem resilience (FEWSNET 2008). Cowpea (*Vigna unguiculata*) is a very important leguminous source of plant protein that is a substitute for animal protein. It has two major varieties – the brown and the white cowpeas. Cowpea trade flows from the drier inland areas to the more humid and densely populated coastal areas. Robinson *et al*. (2014) affirm that most of the cowpea consumed in southern Nigeria is produced and transported from the northern part. Mishili *et al*. (2007) state that the largest cowpea market in the world is Dawanau Market in Kano State, northern Nigeria, which supplies a network of cowpea buyers throughout Nigeria and the neighbouring countries. Merchants from southern Nigerian cities come to Kano to purchase cowpea.

Yam is one of the most frequently consumed staple foods in the country, with a considerable amount of the population consuming yam once or twice per week (International Institute of Tropical Agriculture [IITA] 2013; Phillips *et al*. 2013). The highest yam-producing states in Nigeria are Benue, Niger and Taraba states (Bergh *et al*. 2012). Yam prices fluctuate significantly over the course of the year. The trade flow goes mainly from the north-central region to other regions of the nation (FAO 2008; IITA 2013). Yam is a preferred food security stem tuber crop because, unlike other root tuber crops, yam tubers can be stored for periods up to about four to six months at ambient temperature. According to the International Fund for Agricultural Development ([IFAD] 2010), there is a need to concentrate on Nigerian yam markets due to their importance and profitability. The prices of these commodities (i.e. yam and cowpeas) are usually unstable between seasons and across regions in Nigeria (NISER 2008; Bergh *et al*. 2012; Robinson *et al*. 2014). Cowpea and yam production in Nigeria are concentrated in the Northern part of the country, and Akinseye (2011) has reported that trade flows within Nigeria are mostly commodity and regional based, with some geo-political zones having a comparative advantage for the production of certain commodities. Trade usually flows from such production points to various consumption points. These flows are affected by fluctuations in agricultural commodity prices, which occur between production seasons, distances, bad roads and numerous other shocks. Hence, there is need for more empirical evidence about whether or to what extent the prices of food commodities have affected price transmission and the integration of regional food markets, and in particular yam and cowpea markets, which are indigenous to Nigeria.

The above instigated the need to understand the long-run behaviour of Nigerian cowpeas and yam tuber retail prices across space and time vis-à-vis frequency, the response of these prices to shocks within the system, and to make a comparison of the situation before, during and after the world food crisis.

This study is necessary because an understanding of the long-run behaviour of Nigerian yam and cowpea markets across space and time will aid in achieving a distributional balance between food-deficit and food-surplus regions, and further help market intermediaries/participants to identify the possibilities for trading amongst regions, and between markets and commodities. This is because a well-coordinated national food-marketing system can lead to increased food production and food output , and further lead to employment generation for both food distributors and rural farmers, thereby increasing their personal income and enhancing the prospect of food security (FEWSNET 2008; Akpan *et al*. 2014). Knowledge about the degree of closeness of price movements, and of the speed and efficiency of price transmission are prerequisites for achieving efficient allocation of resources across space and time, and for any rational policy on the prices of agricultural products

(Okoh & Egbon 2005). A deeper understanding of how food prices are spatially transmitted amongst markets in Nigeria is thus fundamental for designing policy measures to reduce poverty and food insecurity.

Past studies have addressed linkages between and amongst food commodity markets in Nigeria in several ways using various methods/approaches and scopes, including bivariate methods. Lütkepohl (1991), however, explains that the use of several variables can help avoid econometric problems caused by a potential omitted variable bias. In the light of this, this work employed the multivariate approach in its analytical framework.

To this end, this work will be a valuable source of information for policymakers, producers and consumers, and also will assist in the formulation of price policies that would lead to proper planning, and the promotion of efficiency in agricultural products markets in Nigeria in general, and in the various regional markets in particular.

The remainder of the paper is organised as follows: Section 2 presents the theoretical and empirical frameworks. Section 3 describes the data and methodology. The results are discussed in Section 4, while Section 5 provides the summary.

2. Theoretical and empirical frameworks

Co-integration theory states that two or more non-stationary series are long-term co-integrated if both series are integrated of the same order and their linear combination yields a disturbance term that is stationary (Johansen & Juselius 1990). Numerous works have been done on price transmission using different models, commodities, years, localities and results. Early studies on spatial market integration used the static approach, that is the bivariate correlation model and Ravallion model. These models, however, fail to examine the dynamic analysis of market integration, such as the extent to which markets are integrated, the direction of co-movement of prices in different spatial markets, the short-run disequilibrium situations, as well as the long-run equilibrium adjustment between prices. Ben-Kaabia and Gil (2007) investigated the non-linear adjustment of prices between farm and retail prices in the lamb sector in Spain using a three-regime threshold autoregressive model. A limitation of the threshold autoregressive model is the assumption of constant transaction costs in proportional terms, which implies a fixed neutral band over the period of study (but it may not be constant in the long run and may be non-stationary) (Fackler & Goodwin 2001). The Johansen testing procedure has also been used. It has the advantage that it allows for the existence of more than one co-integrating relationship, and the speed of adjustment towards the long-term equilibrium is easily determined. However, it does not make use of transaction costs. The procedure is easy and can be applied to a model using more than two variables. This study adopted the Johansen testing procedure. Esposti and Listorti (2011) used the vector error-correction model to investigate agricultural price transmission in cereal, both across different market places and across different commodities during price bubbles. The empirical framework chosen for this work was based on the works of Esposti and Listorti (2011) and Mafimisebi *et al*. (2013).

3. Description of data and methodology

3.1 Data collection and sample size

This study focused on six states (Adamawa, Kano, Niger, Oyo, Cross River and Enugu) selected from the six geopolitical zones of Nigeria. The monthly retail prices of three commodities (fresh yam tubers, white cowpeas and brown cowpeas) were investigated in each of the states. These data were collected from the selected states' agricultural development programmes (ADP) offices, and the

National Bureau of Statistics (NBS). The study period was from January 2000 to December 2015. This gives 16 years (192 months).

3.2 Analytical techniques and data analysis

The unit root test, Granger causality test, Johansen co-integration test, vector error-correction model (VECM) and the variance decomposition analysis were used in the analysis.

- A general analysis was conducted on each market from 2000 to 2015.
- The monthly retail price series for each commodity was divided into three groups: Group I = pre-crisis period (2000 to 2006); group II = crisis period (2007 to 2011), and group III = post-crisis period (2012 to 2015).

3.2.1 Unit root test: Augmented Dickey Fuller test (ADF)

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

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 hypotheses tested were:

H_o: The series contains a unit root

H_A: There is no unit root

If the unit root test confirms the presence of a unit root (at level) in the price series, and the price series have to be differenced by the same order to attain stationarity, then the co-integration test is run (Okoh & Egbon 2005).

3.2.2 Co-integration test

To test whether the markets co-integrate, the Johansen multivariate co-integration test procedure was followed. The presence of at least one co-integrating relationship is necessary for the analysis of a long-run relationship between the prices to be possible. Thus, a model for co-integration analysis was specified in line with Johansen and Juselius (1990), as below:

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

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 (Esposti & Listorti 2011).

3.2.3 Granger causality test

The Granger causality test was used to determine whether price movements follow defined paths. This test is one of the important econometric tools used to determine whether past change in a time-series variable, say "X", has an influence on the current variable, "Y", or whether the relationship works in the opposite or bilateral direction. A time-series X is said to show Granger causality with another Y if it can be confirmed (usually through a series of tests on lagged values of X, and with lagged values of Y also included) that those X values provide statistically significant information about future values of Y (Akpan *et al*. 2014). The model for Granger causality testing for this analysis, derived from Mafimisebi *et al*. (2013), was represented thus:

$$lnP_{1t} = \psi_0 + \sum_{i=1}^{n} \psi_{1i} lnP_{1(t-i)} + \sum_{i=1}^{n} \psi_{2i} lnP_{2(t-i)} + \varepsilon_t \quad (3)$$

$$lnP_{2t} = \vartheta_0 + \Sigma_{i=1}^{n} \vartheta_{1i} lnP_{1(t-i)} + \Sigma_{i=1}^{n} \vartheta_{2i} lnP_{2(t-i)} + \varepsilon_t, \quad (4)$$

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; $\psi_{i's}$ *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.

3.2.4 VECM model

To evaluate the speed of adjustment of prices amongst the markets that co-integrate, a vector error-correction model (VECM) was specified 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 & Granger 1987).

$$\Delta lnP_{it} = \tau_0 + \Sigma_{i=1}^{n} \tau_{1i} \Delta lnP_{i(t-i)} + \Sigma_{i=1}^{n} \tau_{2j} \Delta lnP_{j(t-i)} + \phi ECM_{(t-1)} + \varepsilon_{1t} \quad (5)$$

$$\Delta lnP_{jt} = \omega_0 + \Sigma_{i=1}^{n} \omega_{1i} \Delta lnP_{i(t-i)} + \Sigma_{i=1}^{n} \omega_{2j} \Delta lnP_{j(t-i)} + \phi ECM_{(t-1)} + \varepsilon_{2t}, \quad (6)$$

where P_{it} and P_{jt} = price series of markets *i* and *j*; Δ = the difference operator; $P_{i(t-1)}$ and $P_{j(t-1)}$ = lagged prices in markets *i* and *j*; τ_0 *and* ω_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).

3.2.5 The variance decomposition (VD) analysis

The VD analysis was used to assess the dynamic interactions amongst the markets under consideration. It showed how much of a change in a market is due to its own shock and how much is due to shocks to other markets.

4. Empirical results

4.1 Results of the ADF unit root test

Table 1 shows the result of the ADF tests (at levels and at first differences) on the variables.

Table 1: The augmented Dickey Fuller (ADF) unit root test results for the period 2000 to 2015

Market	Test at level		Test at 1st difference	
	ADF_{NT}	ADF_{WT}	ADF_{NT}	ADF_{WT}
Yam				
Adamawa	-1.17	-2.18	-12.13**	-12.41**
Cross River	-1.92	-2.80	-12.30**	-9.80**
Enugu	-2.31	-2.97	-9.27**	-10.41**
Kano	-2.04	-3.16	-11.74**	-10.53**
Niger	-2.11	-2.28	-7.78**	-8.31**
Oyo	-1.22	-3.11	-6.54**	-9.76**
Brown cowpea				
Adamawa	-0.14	-3.25	-7.26**	-13.49**
Cross River	-1.31	-3.02	-16.96**	-9.76**
Enugu	-1.67	-3.29	-4.25**	-11.23**
Kano	-1.97	-2.64	-13.42**	-17.89**
Niger	-1.91	-3.36	-7.29**	-12.54**
Oyo	-1.71	-2.98	-5.38**	-6.11**
White cowpea				
Adamawa	-1.06	-2.80	-20.05**	-21.31**
Cross River	-1.41	-2.48	-13.19**	-14.11**
Enugu	-2.24	-2.83	-15.59**	-11.02**
Kano	-2.13	-2.92	-15.53**	-15.77**
Niger	-2.78	-1.64	-16.55**	-17.34**
Oyo	-1.44	-3.32	-19.74**	-20.00**

Note: the critical values at 5% are -2.87 for the model without trend (NT) and -3.43 for the model with trend (WT). ** indicates the rejection of the null hypothesis of the presence of the unit root at the 5% level of significance. Source: Authors' calculations using data from the states' ADP offices and the office of the National Bureau of Statistics (NBS) in 2018.

The augmented Dickey Fuller (ADF) unit root test results in Table 1 showed that the variables contained a unit root (were not stationary) at level, and had to be differenced once to be stationary. Table 1 shows that the values at levels (in absolute terms) are less than the critical values (as displayed in the note), while the test result in the first difference column reveal that the price series became stationary at first difference (the test values in absolute terms are higher than the critical values).

4.2 Long-run relationships amongst the markets

The results of the Johansen multivariate co-integration test (both the trace and maximum eigenvalue tests) in Table 2 confirm the presence of long-run relationship amongst the markets.

The results displayed in Table 2 suggest the presence of some degree of marketing efficiency in yam and cowpea markets in Nigeria. It can be seen that r = 0 is significant, which shows evidence of a co-integrating vector. It further reveals that, during the crisis period (2007 to 2011), the yam and brown cowpea markets were more co-integrated than in the other periods (as the number of their co-integrating equations increased). However, in the post-crisis period, while the yam and brown cowpea markets remained co-integrated, the white cowpea market did not share any long-run relationship. Thus, it can be said that the markets studied were more bound together during the food crisis period from 2007 to 2011 than in the other periods. There is reason to suggest that arbitrage, which binds the prices together over time, is a possible contribution to integration. This finding corroborates the

study carried out by Okoh and Egbon (2005), who associated the long-run integration of market food products with arbitrage.

Table 2: Results of Johansen multivariate co-integration test

Null hypothesis	Full sample		Pre-crisis		Crisis		Post-crisis	
	λ_{trace}	λ_{max}	λ_{trace}	λ_{max}	λ_{trace}	λ_{max}	λ_{trace}	λ_{max}
Yam markets								
r = 0	110.77*	48.24*	129.99*	53.88*	122.13*	44.46*	96.86*	42.38*
r ≤ 1	62.53	22.94	76.12	27.13	77.67*	34.50*	54.48	24.35
r ≤ 2	39.59	13.92	48.99	22.56	43.18	24.49	30.13	17.15
r ≤ 3	25.67	12.14	26.43	12.25	18.69	11.25	12.98	6.97
r ≤ 4	13.53	9.46	14.18	7.38	7.44	7.42	6.01	5.56
r ≤ 5	4.07	4.07	6.80	6.80	0.02	0.02	0.45	0.45
Brown cowpea markets								
r = 0	100.44*	40.33*	181.64*	79.41*	472.96*	211.51*	135.31*	52.48*
r ≤ 1	60.10	25.90	102.22*	45.60*	261.45*	111.32*	82.82*	38.40*
r ≤ 2	34.20	13.56	56.62*	27.67*	150.13*	73.48*	44.42	25.28
r ≤ 3	20.64	11.17	28.95	20.51	76.66*	45.42*	19.14	15.22
r ≤ 4	9.47	8.73	8.45	6.16	31.24*	30.15*	3.93	3.43
r ≤ 5	0.74	0.74	2.29	2.29	1.08	1.08	0.49	0.50
White cowpea markets								
r = 0	134.97*	48.74*	127.33*	46.56*	97.48*	41.05*	81.75	33.57
r ≤ 1	86.24*	42.63*	80.76	34.80	58.44	25.67	48.18	18.06
r ≤ 2	43.62	23.44	45.96	22.19	32.77	17.96	30.12	13.80
r ≤ 3	20.17	11.89	23.76	14.55	14.81	11.17	16.32	8.50
r ≤ 4	8.28	7.65	9.21	7.82	3.64	3.63	7.82	5.18
r ≤ 5	0.63	0.63	1.39	1.39	0.01	0.01	2.65	2.65

* denotes rejection of the hypothesis of no co-integration at the 0.05 level: Source: Authors' calculations using data from the states' ADP offices and the NBS in 2018.

4.3 Direction of price leadership

The Granger causality test results in Table 3 reveal the direction of price leadership between the various markets.

In the yam markets section (full sample), a unidirectional (strong exogeneity) causality runs from Kano to Adamawa, and to Cross River. This means that past prices of yam in Kano State can be used to predict prices of yam in Adamawa and Cross River states. A bidirectional causality can be seen between Adamawa and Niger; Cross River and Niger; Enugu and Niger; Kano and Niger; Kano and Oyo; and Niger and Oyo states.

The brown cowpea markets section reveals a strong exogeneity causality running from Kano to Enugu; Niger to Adamawa; Niger to Cross River; Niger to Enugu; Niger to Kano; Niger to Oyo; and Oyo to Kano. The implication of this is that the brown cowpea prices in all the states studied depend on past prices bf Brown cowpeas in Niger State. This finding supports the affirmation of Robinson *et al*. (2014) that brown cowpea in Nigeria comes from the North Central region of the nation. Hence, the brown cowpea price in Niger State can be used to forecast the brown cowpea prices in the other states. A bi-causal relationship exists between Adamawa and Oyo cowpea markets, while no causality runs in the other market pairs.

In the white cowpea markets, the past price in Niger State can be used to predict the prices in Adamawa, Kano and Enugu states, while the past price of white cowpea in Kano helps in predicting the white cowpea prices in Adamawa, Enugu and Oyo. The Cross River past prices predict those of Enugu and Oyo.

Table 3: Results of Granger causality test

Markets	Full sample	Pre-crisis	Crisis	Post-crisis
Yam markets				
Adamawa – Cross River	4.12 (0.84)	8.32** (0.02)	1.25 (0.86)	6.37 (0.17)
Cross River – Adamawa	3.98 (0.85)	6.23* (0.07)	3.59 (0.46)	6.06 (0.19)
Adamawa – Enugu	3.75 (0.87)	3.02 (0.22)	5.86 (0.20)	2.91 (0.57)
Enugu – Adamawa	12.97(0.11)	1.72 (0.42)	2.61 (0.62)	11.82** (0.01)
Adamawa – Kano	6.78 (0.55)	2.67 (0.26)	3.99 (0.26)	15.30*** (0.00)
Kano – Adamawa	14.80* (0.06)	11.60*** (0.00)	8.92* (0.08)	8.99* (0.06)
Adamawa – Niger	16.48*** (0.00)	2.62 (0.26)	4.02 (0.40)	4.21 (0.37)
Niger – Adamawa	22.2*** (0.00)	17.19*** (0.00)	14.29*** (0.00)	21.00*** (0.00)
Adamawa – Oyo	10.15 (0.25)	1.74 (0.41)	1.52 (0.82)	5.97 (0.20)
Oyo – Adamawa	8.09 (0.42)	0.65 (0.72)	5.19 (0.26)	19.06*** (0.00)
Cross River – Enugu	7.41 (0.49)	1.22 (0.54)	5.94 (0.20)	1.74 (0.78)
Enugu – Cross River	2.37 (0.96)	11.88*** (0.00)	2.75 (0.60)	1.27 (0.86)
Cross River – Kano	5.22 (0.75)	0.02 (0.98)	6.2 (0.18)	8.46* (0.07)
Kano – Cross River	16.08** (0.05)	9.99** (0.04)	5.55 (0.23)	5.10 (0.27)
Cross River – Niger	27.86*** (0.00)	7.58** (0.04)	4.25 (0.37)	10.42** (0.03)
Niger – Cross River	14.77* (0.06)	2.41 (0.29)	0.13 (0.99)	4.97 (0.28)
Cross River – Oyo	11.9 (0.15)	4.22 (0.12)	3.70 (0.43)	5.01 (0.28)
Oyo – Cross River	12.22 (0.14)	10.59*** (0.00)	4.19 (0.37)	3.77 (0.43)
Enugu – Kano	9.35 (0.31)	0.50 (0.77)	8.76* (0.06)	28.86*** (0.00)
Kano – Enugu	6.45 (0.59)	1.37 (0.50)	10.52** (0.03)	12.30** (0.01)
Enugu – Niger	15.39*** (0.00)	2.00 (0.36)	21.80*** (0.00)	6.07 (0.19)
Niger – Enugu	15.90***(0.00)	9.89** (0.01)	8.68* (0.06)	4.45 (0.36)
Enugu – Oyo	7.77 (0.45)	7.27* (0.07)	8.30* (0.08)	48.35*** (0.00)
Oyo – Enugu	5.30 (0.72)	7.46** (0.02)	9.43** (0.05)	6.86 (0.14)
Kano – Niger	13.82* (0.08)	0.15 (0.92)	8.69* (0.06)	4.02 (0.40)
Niger – Kano	14.49* (0.07)	1.41 (0.49)	7.94* (0.09)	18.71*** (0.00)
Kano – Oyo	17.36*** (0.00)	3.14 (0.20)	3.89 (0.42)	1.52 (0.82)
Oyo – Kano	13.41* (0.09)	0.11 (0.94)	1.48 (0.82)	35.22*** (0.00)
Niger – Oyo	22.59*** (0.00)	10.25*** (0.00)	15.62*** (0.00)	17.03*** (0.00)
Oyo – Niger	28.49*** (0.00)	10.77*** (0.00)	3.92 (0.41)	6.97 (0.13)
Brown cowpea markets				
Adamawa – Cross River	3.55 (0.93)	20.91*** (0.00)	0.12 (0.94)	0.10 (0.94)
Cross River – Adamawa	4.44 (0.88)	4.44 (0.72)	0.75 (0.68)	4.43 (0.10)
Adamawa – Enugu	14.64 (0.10)	15.45** (0.03)	10.22*** (0.00)	2.4 (0.29)
Enugu – Adamawa	6.66 (0.67)	19.02*** (0.00)	4.37 (0.11)	7.34** (0.02)
Adamawa – Kano	11.73 (0.22)	5.52 (0.59)	0.94 (0.49)	0.16 (0.92)
Kano – Adamawa	6.36 (0.68)	10.72* (0.09)	0.07 (0.96)	11.83*** (0.00)
Adamawa – Niger	11.34 (0.25)	1.56 (0.97)	1.63 (0.44)	11.76*** (0.00)
Niger – Adamawa	21.88*** (0.00)	16.55** (0.01)	5.78** (0.05)	7.52** (0.02)
Adamawa – Oyo	17.13** (0.04)	8.08 (0.32)	0.17 (0.91)	1.00 (0.60)
Oyo – Adamawa	16.16* (0.06)	14.67** (0.05)	4.60* (0.09)	3.3 (0.18)
Cross River – Enugu	3.70 (0.93)	7.82 (0.34)	0.27 (0.87)	0.54 (0.76)
Enugu – Cross River	8.58 (0.47)	17.24** (0.01)	0.69 (0.70)	0.37 (0.82)
Cross River – Kano	10.46 (0.31)	8.15 (0.31)	0.29 (0.86)	10.27*** (0.00)
Kano – Cross River	9.22 (0.41)	15.12* (0.03)	4.35 (0.11)	0.80 (0.66)
Cross River – Niger	6.23 (0.71)	13.75* (0.08)	1.28 (0.52)	0.55 (0.75)
Niger – Cross River	19.04** (0.02)	4.59 (0.70)	0.07 (0.96)	2.49 (0.28)
Cross River – Oyo	4.67 (0.86)	7.91 (0.34)	3.62 (0.16)	0.78 (0.67)
Oyo – Cross River	12.02 (0.21)	12.42* (0.08)	2.15 (0.34)	0.32 (0.84)
Enugu – Kano	7.21 (0.61)	14.04** (0.05)	0.07 (0.96)	0.13 (0.90)
Kano – Enugu	16.89** (0.05)	4.14 (0.78)	4.98* (0.08)	10.27*** (0.00)
Enugu – Niger	12.08 (0.20)	7.15 (0.41)	0.80 (0.66)	0.25 (0.90)
Niger – Enugu	19.13** (0.01)	9.98 (0.18)	6.62** (0.03)	7.53** (0.02)
Enugu – Oyo	10.26 (0.32)	15.45** (0.03)	0.85 (0.65)	2.16 (0.33)
Oyo – Enugu	17.91** (0.03)	6.92 (0.43)	1.10 (0.57)	0.43 (0.80)
Kano – Niger	14.23 (0.11)	2.56 (0.92)	0.54 (0.76)	3.03 (0.21)

Niger – Kano	21.83*** (0.00)	4.40 (0.73)	4.78* (0.09)	3.12 (0.20)
Kano – Oyo	8.29 (0.50)	12.80* (0.07)	0.22 (0.19)	0.84 (0.65)
Oyo – Kano	20.34*** (0.00)	2.33 (0.93)	0.76 (0.68)	0.21 (0.89)
Niger – Oyo	18.08** (0.03)	23.59*** (0.00)	0.75 (0.68)	2.70 (0.25)
Oyo – Niger	14.10 (0.11)	3.05 (0.88)	0.78 (0.67)	1.42 (0.49)
White cowpea markets				
Adamawa – Cross River	1.80 (0.41)	4.68 (0.69)	3.45 (0.17)	
Cross River – Adamawa	1.61 (0.44)	13.85** (0.05)	0.89 (0.63)	
Adamawa – Enugu	1.11 (0.57)	29.87*** (0.00)	3.40 (0.18)	
Enugu – Adamawa	2.45 (0.29)	14.62** (0.04)	0.37 (0.83)	
Adamawa – Kano	3.36 (0.18)	5.92 (0.54)	4.01 (0.13)	
Kano – Adamawa	22.6*** (0.00)	10.06 (0.18)	0.81 (0.66)	
Adamawa – Niger	0.58 (0.74)	8.70 (0.27)	1.07 (0.58)	
Niger – Adamawa	7.12** (0.02)	9.22 (0.23)	2.33 (0.31)	
Adamawa – Oyo	0.97 (0.61)	3.20 (0.86)	0.98 (0.611)	
Oyo – Adamawa	2.83 (0.311)	12.49* (0.08)	6.33** (0.04)	
Cross River – Enugu	8.66** (0.01)	5.72 (0.57)	0.11 (0.99)	
Enugu – Cross River	2.63 (0.26)	10.07 (0.18)	0.10 (0.94)	
Cross River – Kano	1.98 (0.63)	12.87* (0.07)	5.00* (0.08)	
Kano – Cross River	0.40 (0.81)	5.82 (0.56)	1.49 (0.47)	
Cross River – Niger	1.76 (0.41)	1.76 (0.97)	0.75 (0.68)	
Niger – Cross River	9.21 (0.00)	8.82 (0.32)	0.22 (0.89)	
Cross River – Oyo	0.41** (0.81)	4.91 (0.67)	0.38 (0.84)	
Oyo – Cross River	4.12 (0.13)	11.09 (0.13)	3.62 (0.16)	
Enugu – Kano	3.25 (0.19)	5.67 (0.57)	0.32 (0.84)	
Kano – Enugu	10.06*** (0.00)	32.16*** (0.00)	0.28 (0.86)	
Enugu – Niger	0.42 (0.81)	2.59 (0.92)	0.60 (0.72)	
Niger – Enugu	21.48*** (0.00)	26.75*** (0.00)	2.40 (0.30)	
Enugu – Oyo	2.29 (0.31)	11.01 (0.13)	0.46 (0.79)	
Oyo – Enugu	0.15 (0.92)	9.62 (0.21)	0.58 (0.74)	
Kano – Niger	3.91 (0.14)	6.49 (0.48)	5.38* (0.06)	
Niger – Kano	6.22** (0.04)	17.62** (0.01)	6.57** (0.03)	
Kano – Oyo	7.85** (0.01)	18.65** (0.01)	0.82 (0.66)	
Oyo – Kano	2.94 (0.22)	10.08 (0.18)	2.75 (0.25)	
Niger – Oyo	1.59 (0.45)	30.22*** (0.00)	1.13 (0.56)	
Oyo – Niger	5.03** (0.08)	4.35 (0.73)	1.68 (0.43)	

*, ** and *** denote failure to accept the null hypothesis of no causality at the 10%, 5% and 1% levels of significance, respectively

Source: Authors' calculations using data from the states' ADP offices and the NBS in 2018

4.4 Speed of adjustment to equilibrium

A VECM was specified for all market groups, except for the white cowpea markets in the period from 2012 to 2015 (due to a lack of co-integration). The results are shown in Table 4.

Table 4 reveals that, in the yam market, as many as 98% of the disequilibrium in price after the crisis was restored within one month in Kano State, while only 4% of price disequilibrium was restored within a month in Enugu State during the crisis period. This means that it took between one month (Kano in post-crisis) and two years (Enugu in crisis period) for the price in the yam market to normalise after a price instability. The brown cowpea market had a faster speed of adjustment to equilibrium, which ranged between one month (98% of price distortion restored within a month in Adamawa in the pre-crisis period) and eight months (12% of price distortion was restored in Oyo in the period from 2001 to 2015). The speed of adjustment to equilibrium in the white cowpea market ranged between one and a half months (85% of price distortion restored in Adamawa in pre-crisis) and two years (5% of the price distortion was restored in a month in Cross River in the crisis period).

Table 4: Table of error correction terms (ECT)

Market	Whole sample	Pre-crisis	Crisis	Post-crisis
Yam markets				
Adamawa	-0.13**	-0.63***	0.02	-0.90***
Cross River	0.12*	0.96***	0.01	0.68
Enugu	0.009	-0.06*	-0.04*	-0.19*
Kano	-0.017	0.16	-0.17**	-0.98***
Niger	-0.62***	-0.40**	0.10***	-0.91**
Oyo	-0.05**	-0.08**	-0.04	-0.65
Brown cowpea markets				
Adamawa	-0.17**	-0.98**	-0.37**	-0.25***
Cross River	-0.01	-0.91***	0.02	0.02
Enugu	-0.02	-0.38*	0.24***	0.01
Kano	-0.21**	0.65	0.15	-0.14**
Niger	-0.32**	-0.39*	-0.20	-0.15***
Oyo	-0.12***	0.13	0.13	0.08
White cowpea markets				
Adamawa	-0.12**	-0.85***	-0.24**	-
Cross River	-0.09**	-0.63**	-0.05*	-
Enugu	-0.02	0.43**	-0.06*	-
Kano	-0.06	-0.17**	0.33***	-
Niger	-0.12**	-0.19*	0.34**	-
Oyo	-0.09***	-0.23**	-0.19**	-

Note: *, ** and *** denote the 10%, 5% and 1% levels of significance respectively. Significant positive values mean inability to return to equilibrium after a price shock, while significant negative values show the rate of readjustment to the equilibrium/steady price after a price shock.
Source: Authors' calculations using data from the states' ADP offices and the NBS in 2018

Generally, the three commodities' markets returned to a steady state at different rates. Their speed of adjustment to equilibrium was also slow, and this was worst in the yam and brown cowpea markets during the crisis period. This implies sluggishness and supports the conclusions of Okoh and Egbon (2005) and of NISER (2008), namely that the food price inflation in Nigeria cannot be isolated completely from the trend in food supply in the country which is suspected to be too slow. Yam markets, however, readjusted better than the other markets. When comparing the periods, the markets responded faster to disequilibrium in their system in the pre-crisis period than in other periods. Adamawa State appeared to adjust faster to equilibrium than the other states. This may be attributed to the fact that Adamawa State receives support from the national and international community.

4.5 Shock spill-overs

Table 5 gives a summary of the decomposition of shocks in each variable by the 10^{th} period (10^{th} month) using the whole sample and the crisis period samples. It further shows the percentages of change (i.e. highest and lowest) in a market that emanated due to shocks in other markets.

Table 5 reveals that, in the whole sample period, over 50% of price distortions in the yam and brown cowpea markets were due to own shock (or individual market functioning), whereas for the white cowpea markets, the Kano and Niger markets had over 50% of their price shocks coming from other markets. An almost similar trend was seen in the crisis period column. The implication of this result is that most price shocks in the markets studied (except for the Niger and Kano white cowpea markets) were caused by internal market functioning. This affirms the assertion of NISER (2008) that market imperfections are known to create local food supply shortfalls in some parts of the country, while there are surpluses in other parts.

Table 5: Summary of the decomposition of shocks as at the 10th period in the whole sample and during the crisis periods

Market	Variance decomposition for the whole sample			Variance decomposition in the crisis period		
	Own shock (%)	Shocks from others		Own shock (%)	Shocks from others	
		Highest (%)	Lowest (%)		Highest (%)	Lowest (%)
Yam market						
Adamawa	81	8 (Niger)	2 (Oyo)	74	9 (CR)	3 (Oyo)
Cross River	82	6 (Niger)	1 (Adamawa)	80	6 (Enugu)	2 (Adamawa)
Enugu	91	5 (CR)	0.4 (Oyo)	55	17 (CR)	5 (Adamawa)
Kano	84	5 (Oyo)	2 (Niger)	48	25 (CR)	2 (Adamawa)
Niger	63	12 (Enugu)	4 (Adamawa)	34	23 (CR)	5 (Oyo)
Oyo	82	8 (CR)	2 (Adamawa)	31	32 (CR)	4 (Adamawa)
Brown cowpea market						
Adamawa	69	22 (Niger)	0.9 (Kano)	44	41 (Niger)	2 (Kana)
Cross River	73	12 (Kano)	2 (Adamawa)	88	11 (Kano)	0.1 (Enugu)
Enugu	74	9 (Adamawa)	1 (CR)	50	20 (Adamawa)	3 (CR)
Kano	53	20 (Adamawa)	3 (CR)	50	13 (Adamawa)	7 (Enugu)
Niger	58	19 (Adamawa)	0.9 (CR)	78	7 (Kano)	4 (Enugu)
Oyo	51	33 (Niger)	2 (Enugu)	69	12 (Niger)	1 (Enugu)
White cowpea market						
Adamawa	63	13 (Niger)	0.2 (CR)	50	26 (Kano)	0.7 (Enugu)
Cross River	72	14 (Kano)	0.4 (Oyo)	76	21 (Adamawa)	0.0 (Enugu)
Enugu	88	7 (Kano)	0.4 (CR)	94	3 (Niger)	0.5 (Kano)
Kano	48	32 (Oyo)	2.1 (CR)	42	25 (Oyo)	3 (Niger)
Niger	44	17 (Oyo)	2.2 (CR)	68	22 (Enugu)	0.7 (Kano)
Oyo	66	16 (Kano)	0.4 (CR)	64	23 (Kano)	0.2 (CR)

Note: CR = Cross River

Source: Authors' calculations using data from the states' ADP offices and the NBS in 2018

5. Summary and recommendations

The findings of this study confirm evidence of price transmission and long-run relationship across space and time in Nigeria, and contradicts the assertion of low agricultural commodity market integration in the country, which generally is attributed to the fragmented distribution system and often inefficient transportation system. The yam and brown cowpea markets had a stronger relationship during the crisis period, while the relationship within the white cowpea markets was stronger in the pre-crisis period than in the other periods. We attribute the variations in the prices of the commodities in the various markets more to the internal functioning of the specific market. This can be proven by the results of the variance decomposition analysis, which shows that only on a few occasions were up to 50% of shocks in a market due to shocks from other markets. The adjustment of most of the markets studied to equilibrium was low. Low ECT signifies sluggishness in the system, in which case the workings of the market may take a longer time to achieve a steady state.

We believe that the existence of long-run relationships in the cowpea and yam markets in Nigeria is a call for marketers and participants to explore the opportunity for gainful trade. However, a regular supply of commodities and other government intervention policies, such as a national pricing policy and a commodity supply from the national reserve, can help markets to get back to equilibrium after a price shock. Hence, market participants should be provided with adequate storage facilities, and also be encouraged to store excess/surplus commodities. Strategies to ensure an adequate and timely supply of the staple commodities studied should concentrate on leading market locations, such as Niger and Kano. In this regard, any policy for the improvement of yam and cowpea markets in Nigeria should be directed towards the identified leading markets – Niger and Kano – for proper implementation. Finally, internal market shocks seem to be the main contributor to the variances in the prices of the food commodities, therefore the government at should constitute a monitoring team

for the supervision of the market participants to check the incidence of market imperfections at the local and state levels.

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