Price Discovery and Volatility of Vertical Integrated Cowpea Markets (Rural-Urban) in Niger State of Nigeria

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Abstract

The study focused on price discovery and volatility of cowpea in the three major urban markets and their respective adjunct rural markets across the zones in Niger state of Nigeria. Monthly time series data spanning from January, 2003 to December, 2016 were used for this study and the data were analysed using descriptive and inferential statistics. The results indicated that Bida market and its adjunct rural market (Lefane market) were found to be more efficient than their counterparts as evident from the cyclical trends of their respective seasonal pattern which were less pronounced. The results of the unit root tests showed that all the price series data of the selected markets were integrated of order 1. Furthermore, the relationship between the urban market price and rural market price in terms of price discovery revealed non-occurrence of hedging in almost all the market periods, with neither urban nor rural market dominating the process of price discovery thus, indicating efficient performance of trading in cowpea by both markets. The extent of volatility in prices of cowpea due to trading was persistent in Kontagora market, and explosive in Bida and Minna markets due to some arbitrage activities in the latter markets. Therefore, the study recommends strengthening of physical infrastructure, use of information and communication technology and well defined transparent agricultural policy-market measures in the state that will help in the development of single uniform economic market in the region in particular and country in general.

Keywords: Price discovery, volatility, seasonal pattern, cowpea market, Nigeria

Introduction

In considering changes in the prices of agricultural commodities, it is imperative to distinguish between changes in trend and mere fluctuations. Changes in trend occur over medium- or long-term periods and are due to structural alterations in the factors affecting supply and demand – in this case food, while volatility, is a technical concept, which refers to changes in rates of price variation over successive periods of time. There is a great deal of volatility when prices are rising and falling frequently. This new round of price increases has focused attention on the issue of volatility and its causes, much more than during the cycle of increases in the past periods. Two important questions emerge in the current context: how much of this increase can be associated to volatility created by short-term factors, and how much do prices converging at a higher level due to structural factors; with respect to volatility, what is the role of factors such as speculation in the markets of agricultural commodities, uncertainty regarding the pace of the recovery of the economy, the application of measures designed to restrict trade, the declining value of the naira, the over-reaction of the agents in the markets to announcements of lower than expected harvests, among others.

The current high volatility in the agricultural commodities markets has important economic implications for Nigeria where cost of living and malnutrition is very high. Sadiq et al. (2016) reported that volatility in the prices of agricultural commodities has always been higher than that of manufactured products. Consequently, dependence on the subsistence farming which account for the marketable surplus is a fundamental cause of instability in the national terms of trade, thus makes the country more vulnerable economically. Volatility in the prices of agricultural commodities can have serious consequences on rural and national economy of the country: losses in economic efficiency, increased food insecurity, more malnutrition, negative impacts on their trade balance, possible social unrest and greater risks for producers, especially small-scale producers, due to uncertainty regarding expected levels of income.

However, there exists broad range of policy instruments available for government institutions to address volatility issue. Though, the ability to apply them will be determine by the level of development of the institutions, the existence of the necessary technical expertise and the commitments they have assumed under trade agreements. The objective of this research is to investigate the incessant volatility of cowpea commodity in the state in order to generate input for further discussions. A review of the literature showed similar studies conducted in other parts of the globe (Zhong et al., 2004; Zapata et al., 2005; Easwaran and Ramasundaram, 2008; Sendhila et al., 2013;Burark et al., 2013; Achal et al., 2015; Bhavani et al., 2015; Sadiq et al., 2016) with no evidence of any study conducted in Nigeria, thus, justifying this attempt. The objectives of the study were to determine the temporal market price behaviour of cowpea in the study area; determine the efficiency of rural and urban cowpea market with respect to price discovery in the study area; and, determine the source and extent of price volatility in the selected cowpea market.

Methodology

The study used monthly time series data sourced from Niger State Bureau of Statistics (NIBS), spanning from January 2003 to December 2016 for one major urban cowpea market with its respective one major adjunct rural market in each of its three agricultural zones (Bida, Kuta and Kontagora). The chosen urban adjunct rural (urban–rural) markets were Bida (Lafene), Minna (Zungeru) and Kontagora (Manigi). Objective 1 was achieved using ordinary least square model, 12 month centre-moving average and intra-year price variation indexes; objective 2 was achieved using seemingly unrelated regression model; while objectives 3 was achieved using GARCH. The three analytical tools used are: one, the ordinary least square (OLS) model—in which the trend component of time series was calculated by using the least square equation:

$$P_t = a_0 + \beta T_t + \varepsilon_t \qquad (1)$$

Where, P_t = price during the year t; T = serial number assigned to the t^{th} year; ε_t = random disturbance term with usual assumptions; a = intercept value; and β = slope.

The second tool was percentage of centred 12-month moving average method, specified as:

$$P_t = \frac{T \times C \times S \times I \times 100}{MA_t \; T \times C} = (S \times I) \qquad (2)$$

Where P_t is an observation on price index for period t, MA_t is moving average at period t, T is trend component, C is cyclical component, S is seasonal component and I is irregular component.

Averaging this over years and adjustment through correction factor provides a better estimate of seasonal index:

$$K = 1200 \div S \qquad (3)$$

Where K is correction factor and S is the sum.

The third tool was the intra-year price variation indexes. The following approaches can be used to precisely measure the intra-year price variation:

Extent of intra-year price rise (IPR):

$$IPR = \frac{HSPI - LSPI \times 100}{LSPI} \quad (4)$$

Where *IPR* is intra-year price rise (expressed in percentage terms), *HSPI* is the highest seasonal price index and *LSPI* is the lowest seasonal price index during the year.

Coefficient of average seasonal price variation (ASPV): This coefficient can be calculated as follows:

$$ASPV = [(HSPI - LSPI) \div \{(HSPI + LSPI)/2\}] * 100 \quad (5)$$

Where *ASPV* is the average seasonal price index variation

Coefficient of variation (CV): The coefficient of variation is a well-known statistical concept and is calculated as:

$$CV = S \times \frac{100}{\overline{P}} \quad (6)$$

Where *CV* is coefficient of variation, *S* is standard deviation of seasonal price indices and *P* is the mean of seasonal price indices.

Augmented Dickey Fuller test: The autoregressive formulation of ADF test with a trend term is given as:

$$\Delta p_t = a + p_{t-1} + \sum_{j=2}^{it} \beta i \Delta p_{it-j+t} + \mathcal{E} \quad (7)$$

Where, p_{it} is the price in market *i* at the time *t*, Δpit $(p_{it} - p_{t-1})$ and a is the intercept or trend term. The joint hypothesis to check the presence of unit root is H_0: $\gamma = \alpha_0 = 0$, using ϕ_1 statistic. Failure to reject the null hypothesis means that the series is non-stationary.

Price discovery using seemingly unrelated regression (SUR): The Garbade and Silber's (GS) approach was used for estimating the efficiency of rural and urban market in terms of price discovery. The basic structure of model is given as:

$$\begin{matrix} Rt \\ Ut \end{matrix} = \begin{matrix} \alpha R \\ \alpha U \end{matrix} + \begin{vmatrix} 1-\beta R & \beta R \\ \beta U & 1-\beta U \end{vmatrix} \begin{matrix} Rt-1ER,t \\ Ut-1EU,t \end{matrix} \quad (8)$$

Where, R_t is the natural logarithm of monthly rural market price at the t^{th} period, U_t is the natural logarithm of monthly urban market price at the t^{th} period, α_R and α_U reflect the constant secular trend in rural and urban markets, respectively. The β_R and β_U reflect the influence of lagged price from one market on the current price in the other market.

In the GS framework, the estimated equations are given as:

$$R_t - R_{t-1} = a_R + \beta_R(U_{t-1} - R_{t-1}) + E_{R,t} \quad (9)$$

$$U_t - U_{t-1} = a_U + \beta_U(R_{t-1} - U_{t-1}) + E_{U,t} \quad (10)$$

$$U_{t-1} - R_{t-1} = a_b + \beta_b(t-1) + E_{b,t} \quad (11)$$

The *basis* was regressed for each time period, on a time variable (*t-1*), where *t* was the time to maturity of the urban market time period; and it was found that the estimated coefficient on time trend (β_b) had turned negative, as expected.

Generalized autoregressive conditional heteroscedasticity (GARCH) model: The representation of GARCH (*p, q*) is given as:

$$Y_t = \alpha + b_1 Y_{t-1} + b_2 Y_{t-2} + \varepsilon_i$$
(autoregressive process) (12)

And the variance of random error is:

$$\sigma^2{}_t = \lambda_0 + \lambda_1 \mu^2{}_{t-1} + \lambda_2 \sigma^2{}_{t-1} \quad (13)$$

$$\sigma^2 t = \omega + \sum_{i=1}^{p} \beta_i \sigma^2{}_{t-i} + \sum_{j=1}^{q} \alpha_i \mathcal{E}^2{}_{t-i} \quad (14)$$

Where, Y_t is the price in the i^{th} period of i^{th} market, *p* is the order of the GARCH term and *q* is the order of the ARCH term. The sum of $(\alpha + \beta)$ gives the degree of persistence of volatility in the series. The closer the sum is to 1, the greater the tendency of volatility to persist for a longer time. If the sum exceeds 1, it is indicative of an explosive series with a tendency to meander away from the mean value.

Results and Discussion

Time trends in prices of cowpea

The results in Table 1 show that between January, 2003 and December, 2016, the market prices of cowpea increased in all the selected markets. However, the increase in price was highest in Zungeru market, followed by Bida market and then Kontagora market. The entire trends in prices for all the selected markets were found to be significant.

Seasonal pattern of cowpea prices

The price indices for all the selected markets were below average (100) in December in all the selected markets; while the indices of prices were above the average (100) from January to March in almost all the markets (Table 2). From the seasonal indices analysis of prices, it can be concluded that when the major portion of the produce was received in the market, the prices were at lowest barring few exceptions. Furthermore, graphically, it can be observed that the prices of cowpea in each of the selected markets exhibit a cyclical trend, with the trend been highly pronounced in Zungeru, Kontagora and Manigi markets; moderately pronounced in Minna market; and less pronounced in Lefane and Bida markets.

Extent of seasonal price variation

For different cowpea markets in Niger state, the intra-year variations in cowpea prices ranged between 18.81 and 66.19%; the value of average seasonal price variation (ASPV) ranged between 17.19 and 49.73% and was highest in Zungeru market and lowest in Bida market (Table 3). For the IPR, it implies that the price rise during the year in these selected markets were between 18.81 and 66.19%; while the ASPV indicates that the average variation in prices during the year for all the selected markets were between 17.19 and 49.73%. The coefficients of variations in all the selected markets were found to be very low, indicating that price fluctuations in all these selected markets were very low.

Lag length selection criteria

Based on democratic principle, the test results as shown in Table 4revealed that the optimum lag length appropriate for the specified variables is lag one (1) because all the information criteria *viz.* Akaike information criterion (AIC), Schwarz Bayesian information criterion (BIC) and Hannan-Quinn criterion (HQC)chose lag one (1) as indicated by the asterisks of the information criteria. This means that in generating ADF and all the subsequent models, the optimum lag length of the time series data should be one (1) in order to obtain more interpretable parsimonious results and avoid biasness of time series due to their sensitive nature towards lag length.

Unit root test

The ADF results of unit root test did not reject the null hypothesis of the presence of unit root for all the price series when the variables were considered at the level, as indicated by the t-statistic values which were greater than the t-critical values at 5% probability level. At the succeeding level, the first differenced series of all the price variables were found to be stationary, as indicated by the t-statistic values which were lower than the t-critical values at 5%probability level. Also, the ADF-GLS results of unit root test show that all the price series variables were non-stationary at level as indicated by t-statistic values which were higher than t-critical at 5% probability level; but at first difference, they became stationary as shown by t-statistic values which were lower than t-critical at 5% probability level, thus, validating robustness of the earlier results generated using ADF-test.

Price discovery of the bivariate vertical integrated markets

The results of the Bida-Lefane market pair, showed six market periods out of the seven helped in the process of price discovery, and neither Bida market nor Lefane market dominate in the price discovery. This implies that this market pair was not satellite of each other in process of price discovery; and there is a convergence of Lefane market and Bida market cowpea prices because prices of cowpea at Lefane market move towards prices of cowpea at Bida market. In addition, it can be inferred that both markets were pure satellite of their counterparts in price discovery in the seventh market period.

In the case of Minna-Zungeru market pairs, all the seven market periods were efficient in price discovery; and in these market periods, non-dominated the process of price discovery. Six market periods out of seven were useful in the process of price discovery of cowpea in Kontagora-Manigi market pair. It implies that these markets are independent of each other in price discovery from first to the sixth market periods, but in the seventh market period they were not efficient in the process of price discovery, thus, a pure satellite of other markets in other regions of the state. The reason might be that the quantity of arrival in either Kontagora or Manigi markets during the seventh market period were low, the need to rely on other markets for price discovery. For certain market periods, price discovery occurred in both markets (bidirectional); and the possible reason could be that the most quantity arrivals occur during the harvest period. On the whole, Minna-Zungeru market pair was more efficient in terms of price discovery (Table 6).

Extent of price volatility in urban and rural markets

The results of GARCH model showed that only GARCH (1,1) model order fit all the different bivariate vertical integrated markets (Table 7). A perusal of the GARCH analysis for two bivariate vertical integrated markets *viz.* Bida-Lefane and Minna-Zungeru, indicated that volatility in their current month prices depends on the information on preceding month prices volatility and volatility on the preceding month prices, which were evident from the significant ARCH and GARCH-term termed family shock. Also, it was evident that volatility in the current month prices of these markets depends on the volatility in the prices of their respective annexed rural markets (external shock), as evident from their estimated coefficients which were different from zero at 10% probability level ($p<0.10$). On the basis of ARCH and GARCH-terms, it was observed that only the sum of the ($\alpha+\beta$) estimated coefficients of Kontagora was closer to 'one', indicating the persistence of volatility in its cowpea prices; while the sum of the ($\alpha+\beta$) estimated coefficients of Bida and Minna markets were greater than 'one', indicating 'explosive' pattern in volatility of cowpea prices in these markets.

The reason for explosive volatility in Bida and Minna markets is that there are some sharp practices such as arbitrage activities which affect allocative efficiency, thus hampering the usefulness of trading in these markets. The reason for persistence volatility in prices of cowpea in Kontagora market is simply linked to its closeness to larger markets of cowpea situated in the neighbouring Kebbi and Sokoto states, thus making trading activities in this market lukewarm.

The diagnostic test results showed that the residuals of the GARCH models were devoid of autocorrelation as evidenced by their respective q-statistics which were not different from 10% risk level, but were not normally skewed as indicated by the chi-square tests which were different from 10% degree of freedom. However, non-normality is not considered a serious problem as data in most cases are not normally distributed.

Conclusions and Recommendations

The present study focused on temporal price behaviour of cowpea in Niger state of Nigeria. It was observed that Bida market and its adjunct rural market (Lefane market) were found to be highly efficient in marketing as evident from the cyclical trends of their respective seasonal pattern which were less pronounced. Findings revealed non-occurrence of hedging in almost all the market periods, an indication of efficient performance of cowpea trading in the state. Persistent price volatility pattern was found in Kontagora market while others (urban) had explosive price volatility pattern due to some arbitrage activities in the latter markets. Based on these findings, the researchers suggest some policies for a more focused and pragmatic approach for increasing the system's efficiency and generating benefits for the farmers:

1. Exclusive market regulation for agricultural commodities which behave quite different from non-agricultural commodities should be established to govern, monitor and regulate the cowpea trade.
2. There is need to strengthen physical infrastructure, use of information and communication technology and well defined transparent agricultural policy-market measures in the state that will help in the development of single uniform economic market in the region in particular and country in general.

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Table 1: Trends in prices of cowpea for all the selected markets

Markets	*Coefficient of linear trend* *Change in price (₦)*
Bida	P = 1.323T - 0.706
Lefane	P = 1.211T– 6.818
Minna	P = 0.989T + 14.314
Zungeru	P = 4.618T – 159.118
Kontagora	P = 1.303T + 3.043
Manigi	P = 1.211T + 5.509

Source: Authors computation, 2017

Table 2: Seasonal indices of monthly prices of cowpea in selected markets (2003-2016)

Months	*Bida*	*Lefane*	*Minna*	*Zungeru*	*Kontagora*	*Manigi*
January	101.17	103.51	103.77	97.37	93.73	96.78
February	104.10	103.60	97.45	103.53	96.19	98.78
March	106.36	103.33	100.40	100.10	99.72	101.65
April	98.82	98.64	102.24	106.79	101.96	98.45
May	98.57	104.29	125.10	100.46	109.79	112.69
June	105.11	106.27	98.77	99.14	94.64	100.74
July	96.53	94.38	98.22	95.94	108.79	107.35
August	105.56	101.65	97.91	95.16	106.89	109.00
September	99.70	100.95	92.66	132.35	97.78	94.08
October	97.85	96.92	94.47	93.60	104.71	99.19
November	96.72	97.13	97.60	95.94	96.31	91.77
December	89.52	89.35	91.43	79.63	89.51	89.52

Source: Authors computation, 2017

Table 3: IPR, ASP and CV of prices in the selected cowpea markets

Market	*IPR (%)*	*ASPV (%)*	*CV*
Bida	18.81	17.19	0.048
Lefane	18.93	17.29	0.049
Minna	36.83	31.10	0.087
Zungeru	66.19	49.73	0.12
Kontagora	22.66	20.35	0.065
Manigi	25.89	22.92	0.069

Source: Authors computation, 2017

Table 4: Lag selection criteria

Lag(s)	*AIC*	*BIC*	*HQC*
1	54.26*	55.07*	54.59*
2	54.52	56.03	55.13
3	54.88	57.09	55.77

Table 5: Unit roots test

Market	*Stage*	*ADF*		*ADF-GLS*		*Remarks*
		T-stat	*P<0.05*	*T-stat*	*T-critical (5%)*	
Bida	Level	-0.394	0.9079	-1.506	-2.93	Non-stationary
	1st Difference	-12.02**	9.04E-026	-16.83**	-2.93	Stationary
Lefane	Level	-0.525	0.884	-1.422	-2.93	Non-stationary
	1st Difference	-10.89**	4.46E-022	-13.06**	-2.93	Stationary
Minna	Level	-1.643	0.095	-4.96	-2.93	Non-stationary
	1st Difference	-15.37**	5.66E-033	-21.40**	-2.93	Stationary
Zungeru	Level	-1.379	0.594	-1.007	-2.93	Non-stationary
	1st Difference	-13.08**	3.25E-029	-17.46**	-2.93	Stationary
Kontagora	Level	-1.173	0.689	-1.95	-2.93	Non-stationary
	1st Difference	-10.92**	3.60E-022	-13.13**	-2.93	Stationary
Manigi	Level	-0.289	0.924	-1.436	-2.93	Non-stationary
	1st Difference	-11.83**	3.73E-025	-15.35**	-2.93	Stationary

Note: ** indicate that unit root at the level or at first difference was rejected at 5 per cent significance

Table 6: Price discovery of pair-wise vertical integrated markets (Urban-Rural)

Market pair	*Market period*	*Estimated coefficients*		*Price*
		Urban (β_S)	*Rural (β_P)*	*discovery*
Bida-Lefane	Jan. 2003- Dec. 2004	0.953 (0.088)***	0.797(0.064)***	Both
	Jan. 2005- Dec. 2006	0.871(0.086)***	0.845(0.082)***	Both
	Jan. 2007- Dec. 2008	0.949(0.120)***	0.643(0.086)***	Both
	Jan. 2009- Dec. 2010	0.943(0.151)***	0.619(0.094)***	Both
	Jan. 2011- Dec. 2012	0.951(0.890)***	0.812(0.080)***	Both
	Jan. 2013- Dec. 2014	1.13(0.033)***	0.867(0.025)***	Both
	Jan. 2015- Dec. 2016	0.352(0.236)^{NS}	0.165(0.119)^{NS}	None
Minna –	Jan. 2003- Dec. 2004	1.03(0.092)***	0.790(0.072)***	Both
Zungeru	Jan. 2005- Dec. 2006	0.985(0.093)***	0.797(0.083)***	Both
	Jan. 2007- Dec. 2008	0.055(0.013)***	3.88(1.177)***	Both
	Jan. 2009- Dec. 2010	1.12(0.127)***	0.623(0.070)***	Both
	Jan. 2011- Dec. 2012	1.21(0.053)***	0.760(0.037)***	Both
	Jan. 2013- Dec. 2014	-0.134(0.025)***	-1.744(0.52)***	Both
	Jan. 2015- Dec. 2016	-0.628(0.059)***	-1.04(0.130)***	Both
Kontagora–	Jan. 2003- Dec. 2004	1.02(0.084)***	0.808(0.063)***	Both
Manigi	Jan. 2005- Dec. 2006	0.964(0.176)***	0.539(0.084)***	Both
	Jan. 2007- Dec. 2008	0.629(0.174)***	0.479(0.127)***	Both
	Jan. 2009- Dec. 2010	1.04(0.104)***	0.819(0.076)***	Both
	Jan. 2011- Dec. 2012	0.620(0.224)***	0.326(0.114)***	Both
	Jan. 2013- Dec. 2014	0.961(0.093)***	0.606(0.080)***	Both
	Jan. 2015- Dec. 2016	0.176(0.235)***	0.156(0.101)^{NS}	Rural

Note: ***, ** and * indicate the significance at 1%, 5% and 10% levels of probability
( ): values in parenthesis are standard errors

Table 7: Estimates of GARCH model for measuring volatility in prices of cowpea from January 2003 to December 2016

Particulars	*Bida market*	*Minna market*	*Kontagora market*
Constant	9.67(2.59)***	-	9.87(3.03)***
External shock			
Lefane market	1.033(0.051)***	-	-
Zungeru market	-	0.224 (0.007)***	-
Manigi market	-		1.05(0.06)***
Family shock			
Alpha (0)	2.35(2.84)^{NS}	70.53 (98.41)^{NS}	105.98(0.686)^{NS}
Alpha (1)	0.28(0.059)***	0.346 (0.07)***	0..862 (0.686)^{NS}
Beta (1)	0.72(0.118)***	0.654 (0.045)***	1.28E-012 (0.033)^{NS}
Log likelihood	-602.54	-	-671.81
GARCH fit	1,1	1,1	1,1
$\alpha + \beta$	1.00	1.00	0.86
Autocor. (Q-stat)	0.696 [0.404]^{NS}	0.814 [0.367]^{NS}	12.739 [0.121]^{NS}
Normality test (χ^2)	480.6[0.000]***	3574.2[0.000]***	389.9[0.000]***

Notes: Figures within the ( ) and [ ] indicate the standard error and probability value
*** ** and * indicate the significance at 1%, 5% and 10% probability levels respectively
NS: Non-significant