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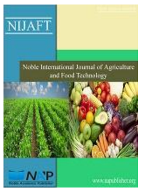

Original Article **Open Access**

CO INTEGRATION AND VECTOR ERROR CORRECTION MODELS ANALYSIS OF PRODUCER PRICES OF CASSAVA, RICE AND MAIZE

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ABSTRACT: This study analyzed the relationship among producer prices of cassava, rice and maize in NNNigeria. The study used annual time series data spanning from 1991 to 2013. Results from Augmented Dickey Fuller test showed that the time series data were not stationary in their level forms but were integrated of order one, I (1). The trace test and maximum Eigen values of Johansen co-integration test indicated 3 co-integrations at the 5 percent level which showed there is a long run relationship among the variables during the period of study.
Nigeria. The study used annual time series data traversing from 1991 to 2013. Results from Augmented Dickey Fuller test indicated that the time series data were not stationary in their level structures but were integrated of order one, 1. The trace test and maximum Eigen values of Johansen co-integration test indicated 3 co-integrations at the 5 percent level which showed there is a long run relationship among the variables during the time of study. The result of the VECM showed the Maize producer price reacted faster than the Cassava and Rice prices. The adjustment coefficient was not statistically significant for the three selected producer prices suggesting that the Cassava and Rice prices are firmly exogenous. This infers that change in Cassava and Rice prices was profoundly influenced by price in Maize while change in price of Maize directed by occasions in cassava and rice prices. This means that the long run equilibrium in the producer prices after exogenous shock was re-established principally by adjustments made by producer prices of maize. Granger causality demonstrated that cassava producer price decided the producer prices of rice and maize which showed a unidirectional causality. Producer prices of rice and maize neither granger caused each other. Hence, the null hypothesis that the producer price does not granger cause each other is rejected. Therefore, price policy in favour of cassava development should be advanced.

Keywords: Co-integration, VECM, Granger Causality, Producer Price, Maize, Cassava, Rice.

1. INTRODUCTION

Agricultural sector is a significant part of Nigerian economy that has added to the Gross Domestic Product of the nation from time long past. In spite of the fact that its contributions had been dropping, comparative with the GDP [1], the sector contributed about 31.9% to the GDP in 2014 [2]. Despite this commitment the crop subsector has failed in meeting the food need of Nigeria masses which is evaluated at 167million (NBS, 2012) prompting high pace of food importation despite the fact that it has been established that food demand is higher than food production in Nigeria [3]. This disappointment is ascribed to a few factors, for example, lack of inputs, use of crude implements, provincial urban movement, low technology adoption, fiascoes among others [4].

2. CEREALS

Cereals are the world's most significant source of food directly for human and by implication as contribution for domesticated livestock feeds. Grains crops include rice, wheat, maize, millet, sorghum, rye, durum among others. The world's production of these crops is projected as 2540 million ton in 2015 and their usage was anticipated as 2536 million tonnes for that year. Nigeria production was estimated as 24.66million metric ton in 2010 which later hoisted to 26.97million metric tons in 2013 (World bank). However, the productivity of crops increases yearly but at an exceptionally low rate and the increase in productivity of these crops is significant in order to satisfy food demand, diminish food importation, lower food cost, and combat malnutrition and poverty. This is clear from the fact that development from agriculture particularly in the crop subsector is at least twice as effective in diminishing poverty as development from different sectors [5].

3. CASSAVA

Cassava (*Manihot esculenta)* is one of the principal root and tuber crops of the tropics generally grown and consumed as subsistence staple [6]. As indicated by Nteranya and Adiel [7], a portion of the convincing explanations behind empowering the development of root and tuber crops for sustainable food production in Africa are:

(i) They are versatile staples fit for tending to food and nutrition security and produce more food per unit area of land, contrasted with numerous different crops
(ii) Though longer in their cropping cycle, are essential in annual cycle of food availability due to their more extensive agro ecological adaptation, various maturity period and in ground storage capacity, allowing adaptability kinfolk harvesting period for supported food accessibility and.
(iii) They are far less susceptible to huge scale market shocks and price speculations experienced by more widely traded staples, such as grains. It is highly productive, it is accessible consistently, and can be prepared into numerous floods, contingent upon nearby traditions and inclination [8]. Cassava production has been expanding for as long as 20 years in area cultivated and in yield per hectare [9]. Nigeria was the world largest producer of cassava in the world with an estimated output of 54 million metric tons in 2013, representing 21% of the world total aggregate [10]. Cassava is also a major cash crop that generates income for a large number of farming households. It is produced in Nigeria to a great extent by small-scale farmers using simple farm implement such as cutlass and hoe.

Producer prices are prices received by farmers for primary crops, live animals and livestock products as collected at the point of initial sale, that is, prices paid at the farm gate [6]. Producer prices are typically an incitement for farmers to produce [11]. According to Ndhlovu and Seshamani [12], farmers are bound to consider past experiences and make the best speculations of the prices. Producer prices may affect the area and yield of cassava. Given the role cassava play as a significant source of staples, availability of cassava products may be influenced by producer prices directly or indirectly through its impacts on area harvested and yield.

4. METHODOLOGY

4.1. Data and Analytical Procedure

Annual time series data on producer prices of cassava, rice and maize spanning from 1991 to 2013 were collected from FAOSTATA [13]. Producer Prices were measured in naira per ton. Given that the study used time series data, a preliminary analysis of the unit root test of producer prices using Augmented Dickey Fuller (ADF) test was carried out to avoid a spurious regression.
Johansen's Maximum likelihood (1991, 1995) co-integration technique was used to examine the long –run relationship among cassava, rice and maize producer prices. The casual relationship among the producer prices was anlysed using Granger causality test [14] and Vector Error Correction Model (VECM) was likewise used to explain the short run relationship among the three crops prices.
ADF test was the initial step to examine the stationary properties of the cassava, rice and maize producer prices. A series is said to be integrated of order d, if a series, for instance $P_{t,}$ is stochastic, invertible and stationary after differencing d times. It is denoted by P_t = I (d). the statistical tests to determine whether the economic variables were order of zero; I (0) or one; I (1) was done using the Johansen test. This was given as follows:

$P_t = \alpha+\beta_1P_{t2}+\beta_2Pt_3+e_t$ …………………………………….. (1)
Where t= time
e_t = residual error term assumed to be distributed identically and independently.
P_{1t}, $P_{2t,}$ P_{3t}= Producer prices series of Cassava, Rice and Maize

When the absolute value of the ADF statistic is smaller than the critical ADF values then the null hypothesis of non-stationary could not be rejected and the next step would be to test whether the first differences are stationary or not. If the null hypothesis of non-stationary can be rejected, then the time series is stationary and if otherwise differencing continues until the time series data is stationary and the order is identified. The series is stationary if /δ/<1, thus testing for stationary property is equivalent with testing for the unit roots (δ<1) under the following hypothesis:

Ho: δ = 0 the price series is non-stationary or there is unit root
H1: δ ≠0 the price series is stationary or there is no unit root i.e. there is white noise in the series

The hypothesis of non-stationary will be accepted at 0.01 or 0.05 levels if ADF is greater than the critical value. The residual from the above equation are considered to be temporary deviation from the long run equilibrium.

$\Delta e_t = \gamma e_{t-1} + \Sigma_{i=1}^{p} \, yi\Delta_{et-1} \; + \sigma_t$ .... (2) [15]

Consider a pair of variables Pt^1 and Pt^2 each of which is integrated of order d their linear relationship can be given by:

$e_{t-1} = P_{1t-1} - \alpha - P_{2t-1}$ … … … … … … … … … . (3) [16]

If the prices series are co-integrated it implies the residuals from the equation follow stationary property. If the linear combination of the two prices is stationary (co integrated), then the residual errors are stationary. The residuals, e_{t-1} from the co-integration equation are stationary if the t-statistic of the coefficient does not exceed the critical value [17], and thus the price series P^{1t} and P^{2t} are co-integrated. At the point when co-integration between times series occurs there is a distinguishing proof of a single market.

4.2. Granger Causality Test

The test recognized the bearing of long-run causal price relationship between the markets (Granger, 1969). The Granger Causality test was employed to identify the leading price in the market among the three crop prices. Granger causality gives additional information with respect to whether, and in which direction, price integration and transmission is occurring between three commodities prices series or market levels. Based on the following pairs of OLS regression equations through a bivariate VAR the test was done.

$$CP_t = \alpha 0 + \Sigma_{i=1}^{m} \alpha_i \, RP_{t=i} + \Sigma_{i=1}^{n} \beta j CP_t = j + \epsilon_t \text{ … … … … … … … … … . (4)}$$

$$RP_t = \alpha_0 + \Sigma_{i=1}^{m} \alpha_i MP_t = i + \Sigma_{i=1}^{n} \beta j RP_t = j + \epsilon_t \text{ … … … … … … … … … . (5)}$$

$$MP_t = \alpha_0 + \Sigma_{i=1}^{m} \alpha_i CP_t = i + \Sigma_{i=1}^{n} \beta j RP_t = j + \epsilon_t \text{ … … … … … … … … … (6)}$$

Where n = number of observations
m = number of lag
CP_t = Cassava Price
MP_t = Maize Price
RP_t = Rice Price
α and β = parameters to be estimated

5. ERROR CORRECTION MODEL (ECM)

In order to demonstrate further on short run interaction causality between the variables and capacity to address long run deviation in the short run, Error Correction Model was used as follows:

$\Delta p_{1t} = \alpha \Sigma \beta_1 \Delta p_{1t-k} + \delta \Delta \hat{e}_{t-1} + \Sigma \beta_2 \Delta p_{2t-k} + \beta_3 \Delta p_{2t} + \varepsilon_t$..(7)

Where β_1, β_2, β_3 = the estimated short run counterparts to the long run solution.
k= the lag length of the time,

δ=the speed of adjustment parameter, which indicates how fast the previous moves back towards long run equilibrium in case of deviation in the previous time period

ε_t =is the stationary random process capturing other information not contained in either lagged value of p_{1t} and p_{2t}

$\hat{e}_{t-1}$ = error correction term, obtained from the co-integration equation captures the deviation from long –run equilibrium.

6. RESULTS AND DISCUSSIONS

6.1. Testing For Stationary: Unit Root Test Results

In order to find out whether the variables or factors were stationary or not, ADF unit root test was applied at ground levels and first differences of the price series. The results are presented in Table 1. The empirical evidence indicates that price series were not stationary in their level form and any attempt to use the non-stationary variables could lead to spurious regression results and such results cannot be used for prediction in the long run.

The null hypothesis which states that producer prices of one crop do not determine prices of another cannot be rejected at $P<0.05$.

When first-differenced, however, the null hypothesis of non-stationarity was rejected in favour of alternative as the values of the ADF t-statistic were greater in absolute term than the critical value. This result is necessary and sufficient for a test of co-integration of the price series.

Table 1. ADF Unit Root Test Results in Levels and First Differences

Producer Prices	At level/First difference	ADF Test	P values	Remarks
Cassava	I (0) I(1)	-1.579905 -7.507380	0.4739 0.0000	Non-stationary Stationary
Rice	I(0) I(1)	-1.440596 -7.531882	0.5419 0.0000	Non-stationary Stationary
Maize	I(0) I(1)	-1.306434 -5.760425	0.6043 0.0002	Non-stationary Stationary

I(0) – Price level and I(1)- first differences
Source: Author's Computation using E-views software computed from Secondary Data, 2017

6.2. Co integration Test Results

Both Trace and Maximum Eigen value statistics show the existence of co-integration relationship at 5 percent significant level for the three crops. To check the null hypothesis that the variables were not co-integrated (r=0), trace and eigen-value statistics were determined; results indicated that the maximum eigen-value and trace statistics values were higher than 5 percent critical values. Therefore, the null hypothesis was rejected and the alternative hypothesis accepted for one or more co-integrating vectors.

Likewise, the null hypothesis; r=0, and $r \leq 1$ both statistics were rejected against their alternative hypothesis of $r \geq 1$

The null hypothesis $r \geq 2$ from both tests (trace test and maximum eigen-value test) were accepted and their alternative hypotheses (r=3) were rejected as the trace value and maximum eigen-value well underneath their corresponding critical values at 5% of significance. The two tests affirmed that all the three chosen crops had 3 co –integrating equations, demonstrating they were very much integrated and price signals were transferred from one crop to another to ensure efficiency. Thus, Johansen co-integration test has shown that though the selected crops in Nigeria were geographically remote zones and spatially sectioned, they were well connected in terms of prices of the crops, demonstrating that the selected crops during study period were co-integrated and had long run price linkage across them. Thus, the cassava, rice and maize producer prices were co-integrated and there existed long run equilibrium. This was supported by earlier studies carried out by Mesike (2012) who inferred that cocoa and rubber market price within Nigeria are highly integrated; and the discoveries of Emokaro and Ayantoyinbo (2014) the outcome showed that the rice markets in Osun State were co-integrated and there existed long run equilibrium.

Table 2. Unrestricted Co-integration Rank Test (Trace)

Unrestricted Co-integration Rank Test (Trace)				
Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.796400	50.78503	29.79707	0.0001
At most 1 *	0.515176	18.95303	15.49471	0.0144
At most 2 *	0.200430	4.473624	3.841466	0.0344
Trace test indicates 3 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized		Max-Eigen	0.05	

No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.796400	31.83200	21.13162	0.0011
At most 1 *	0.515176	14.47941	14.26460	0.0462
At most 2 *	0.200430	4.473624	3.841466	0.0344
Max-eigenvalue test indicates 3 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				

Source: Author’s Computation using E-views software computed from Secondary Data, 2017

6.3. Long Run Relationship Among Producer Prices of Cassava, Rice and Maize

The long run relationship among producer prices of cassava, rice and maize was analysed using the Johansen co-integration test. Results from both the trace and maximum Eigen values are presented in table 2 above. The trace test and maximum Eigen values indicate 3 co-integrations at the 5 percent level. Consequently, the null hypothesis that there is no long run relationship between the producer prices of cassava, rice and maize can be rejected and alternative hypothesis accepted. Hence, this infers that there is long –run relationship among the producer prices of cassava, rice and maize. This then again demonstrates that the variables do move together after some time. The existence of long run relationship also implies that if these variables move away from the mean or equilibrium level, it will be easy to bring them back to equilibrium since there is error correction link among them.

6.4. Short Run Co-integration Relationship

The VECM was utilized so as to investigate the short run dynamics of the effects of producer prices of the three selected crops, having established that a long run relationship existed among the variables. The result of the VECM in table 3 shows that if there is a positive deviation from the long run equilibrium the crop price tends to respond with a reduction or increment in the other crop price. The Maize producer price appears to respond faster than the Cassava and Rice prices. The adjustment coefficient was not statistically significant for the three selected producer prices suggesting that the Cassava and Rice prices are strongly exogenous. This infers that change in Cassava and Rice prices was profoundly influenced by price in Maize while change in price of Maize was directed by occasions in cassava and rice prices. This means that the long run equilibrium in the producer prices after exogenous shock is re-established essentially by rectifications made by producer prices of maize.

The coefficient of the error correction term, which means the speed at which producer prices in the three selected crops change to their long run equilibrium level, was positive but statistically not significant. The coefficient of the error correction term of 2.779211 infers that, the feedback into the short-run dynamics process from the previous period is 277.92% and the positive sign recommends that the change is from a higher price shock (price rise) to the long run price level. This means that the adjustment from the short-run to long –run equilibrium was about 277.92% which is relatively strong compared with the perfect adjustment of 100% threshold. It proposes that the prices of cassava, rice and maize adjust strongly to its long-run level after a price rise (shock). The error correction term has significant element for deciding the timeframe after any deviation from long run equilibrium [16].

Table 3. Short-run Analysis using VECM

Error Correction:	D(CASPPT)	D(RICEPPT)	D(MAIZET)
CointEq1	1.429975	0.850086	2.779211
	(0.39067)	(1.16419)	(1.24322)
	[3.66030]	[0.73020]	[2.23549]

Source: Author’s Computation using E-views software computed from Secondary Data, 2017 Note: All figures in brackets (…) are standard errors and all figures in parenthesis […] are t-values

7. GRANGER CAUSALITY TESTS

The F-statistic for the causality tests of prices of the selected commodities is statistically significant. The VAR-based Granger causality was utilized was utilized to decide if there is any type of causality between the variables and the course of such causality. The result shows that producer price of maize does not granger-cause cassava because of the reality of the p-value is 0.4324 and exceeded 0.05 (Table 4) whereas producer price of cassava can Granger cause that of maize (p-value 0.0491which is almost equal to 0.05). Additionally, producer price of Rice does not granger cause cassava (p-value 0.5506 is more than

0.05) of which cassava producer price can granger cause Rice (p-value 0.0073 is less than 0.05) while rice and maize producer prices cannot granger cause each other. Along these lines, it tends to be concluded that cassava producer price determines the producer prices of rice and maize which shows a unidirectional causality implying that a price change or market shock in cassava causes change in rice and maize while a change in both rice and maize does not essentially granger cause change in cassava production. But if otherwise it is bidirectional causality. Subsequently, the null hypothesis that the producer price does not granger cause each other is rejected.

Table 4. Granger Causality Tests

Pairwise Granger Causality Tests			
Date: 11/07/17 Time: 11:22			
Sample: 1991 2013			
Lags: 2			
Null Hypothesis:	Obs	F-Statistic	Prob.
MAIZEPPT does not Granger Cause CASSAVAPPT	20	0.88703	0.4324
CASSAVAPPT does not Granger Cause MAIZEPPT		3.71040	0.0491
RICE__PADDYPPT does not Granger Cause CASSAVAPPT	20	0.62104	0.5506
CASSAVAPPT does not Granger Cause RICE__PADDYPPT		6.94894	0.0073
RICE__PADDYPPT does not Granger Cause MAIZEPPT	20	0.67231	0.5253
MAIZEPPT does not Granger Cause RICE__PADDYPPT		0.19361	0.8260

Source: Author's Computation using E-views software computed from Secondary Data, 2017

9. CONCLUSION

The result of Johansen co-integration test showed that the chosen crops during study period were well connected and had long run price linkage across them. Thus, the cassava, rice and maize producer prices were co-integrated and there existed long run equilibrium. The result of VECM showed that maize producer price responded faster than cassava and rice. This infers that change in Cassava and Rice prices was profoundly influenced by price in Maize while change in price of Maize was directed by occasions in cassava and rice prices. The adjustment from the short-run to long –run equilibrium was about 277.92% which is moderately strong compared with the perfect adjustment of 100% threshold. It suggests that the prices of cassava, rice and maize adjust strongly to its long-run level after a price shock.

Granger Causality indicated that cassava producer price influenced both rice and maize producers' prices in the market.

Consequently, given the influence of producer price of cassava, good price policies to intensify cassava production should be enhanced.

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