CO-INTEGRATION AND CAUSALITY ANALYSIS IN MAJOR NATURAL RUBBER MARKETS OF NIGERIA

***Agbonkpolor N. B[1], Alufohai G.O , [2] Mesike C.S[1], and Adindu, A.G[1]**
[1]. Rubber Research Institute, Iyanomo, Edo State, Nigeria
[2]. Department of Agricultural Economics, University of Benin. Edo State. Nigeria
* CRRESPONDENCE E-MAIL: nosabetty@yahoo.com

ABSTRACT
The study investigated market integration of natural rubber across three major State markets, namely Edo, Delta and Akwa-Ibom, of the Nigeria using Johansen Co-integration test, and Granger Causality by VECM. Empirical results for average monthly retail price data (N/kg) of natural rubber, covering the period January, 2005 to December, 2015 (11 years) indicated that Price series were not stationary in their level form. The Delta State price appeared to respond faster to changes than the Edo and Akwa-Ibom price. The study also showed the existence of co-integration among the studied markets. Granger causality showed unidirectional causality between Akwa-Ibom and Delta bidirectional for the other two market pairs. The significant coefficient of the error correction term showed immediate adjustment to changes in the long-run equilibrium.

KEYWORDS: Rubber markets, co-integration, Granger causality, price transmission,

INTRODUCTION
Nigeria is the second largest producer of natural rubber in Africa after Cote d'Ivoire and the eleventh in the world, with average annual production of crumb is 143,500 tonnes (Central Bank of Nigeria, 2012), out of which about two-third of it is exported, contributing 1.3% of the world's output of natural rubber (FAOSTAT, 2015).
Currently the rubber industry in Nigeria is facing constraints, which require urgent solutions. Rubber has the potential to help in poverty reduction, but the current production, processing, and marketing techniques being used, do not maximize the potential gains to be realized by farmers who cultivate and market rubber products. The efficiency of the marketing system is crucial in determining the profits from the products. An efficient marketing system is an important means for raising the income levels of farmers and for promoting the economic development of a country (Abolagba *et al,* 2003) and an encouraging factor to improve production. Nigeria has a lot of smallholder rubber farmers who depend solely on the industry as their main source of income. The growers have to depend on various marketing agencies to get a remunerative price for their produce, who in turn depend on rubber processors for affecting their sales. Constraints such as inadequate market information due to lack of marketing research, might have hindered the much anticipated rapid expansion of natural rubber production. It is obvious that the natural rubber sector needs a good marketing system. This necessitates the need to study the market co- integration between the local markets in the study area.

DATA AND METHODOLOGY
Area and Scope of the Study: The study was conducted in Edo, Delta and Akwa-Ibom States. The states were chosen because they are among the major rubber- growing belts in Nigeria. (RRIN 2010).
Data Collection: The data on monthly average rubber price (₦/kg) in Edo, Delta, and Akwa-Ibom markets from January, 2005 to December, 2015 were taken from the Central Bank of Nigeria (CBN), and Food and Agriculture Organization (FAO).

Analytical Procedure:

The co-integration analysis was achieved using Augmented Dickey Fuller Test (ADF), Johansen's maximum likelihood test, Granger causality and the Vector Error Correction Model (VECM) to analyze the time –series data.

The first step is to examine the stationary properties of the various prices using the ADF test. If a series, say P_t, is stationary, invertible and stochastic after differencing d times, it is said to be integrated of order d, and denoted by $P_t = I(d)$. The statistical tests to determine whether the economic variables were I(0) or I(1) using the Johansen test. Alufohai and Ayantoyinbo (2014) formulation test on residual from the co-integration regression is as follows:

$$P_{t1} = \alpha + \beta_1 P_{t2} + \beta_2 P_{t3} + e_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where : t - time

e_t - residual error term assumed to be distributed identically and independently.

P_{1t}, P_{2t} and P_{3t}, - rubber prices series in three markets 1,2 and 3 (Edo, Delta and Akwa-Ibom market prices),

The null hypothesis of non-stationary cannot be rejected, when, the absolute value of the ADF statistic is smaller than the critical ADF value, and the next stage will be to test whether the first differences are stationary. If the null hypothesis of non-stationarity cannot be rejected, then the series is still not stationary. Therefore, differencing continues until the series becomes stationary and order noted. The process is considered stationary if $/\delta/<1$, thus testing for stationary is equivalent with testing for unit roots ($\delta<1$) under the following hypotheses:

Ho: $\delta = 0$ the price series is non-stationary or there is existence of unit root.

H1: $\delta \neq 0$ the price series is stationary or there is white noise in the series.

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

$$\Delta \acute{e}_t = \gamma \acute{e}_{t-1} + \sum_{i=1}^{p} yi \Delta \acute{e}_{t-1} + \delta_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$ (Mussema,2006)

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

$$\hat{e}_{t-1} = p_{1t-1} - \alpha - p_{2t-1} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$ (Fayaz and Naresh 2014).

In order to conclude that the price series are co-integrated the residuals from the equation have to follow stationarity. If the residual errors are stationary then the linear combination of the two prices is stationary (co integrated). If the t-statistic of the coefficient does not exceed the critical value the residuals, $\hat{e}_{t-1}$ from the co-integration equation are stationary (Engle and Yoo, 1987), and thus the price series p_{1t} and p_{2t} are co-integrated. When co-integration between time series is evident there is an identification of a single market.

Granger Causality Test: The test is used to test the existence and the direction of long-run causal price relationship between the markets (Granger, 1969). The granger causality test was used to determine the leading markets between three States markets. Granger causality provides additional evidence as to whether, and in which direction, price integration and transmission is occurring between three price series or market levels. The test was based on the following pairs of OLS regression equations through a bivariate VAR:

$$EP_t = \alpha 0 + \sum_{i=1}^{m} \alpha i \, DPt = i + \sum_{i=1}^{n} \beta j EPt = j + \epsilon t \quad \text{----------} \quad (4)$$

$$DP_t = \alpha 0 + \sum_{i=1}^{m} \alpha i \, APt = i + \sum_{i=1}^{n} \beta j DPt = j + \epsilon t \quad \text{----------} \quad (5)$$

$$AP_t = \alpha 0 + \sum_{i=1}^{m} \alpha i \, EPt = i + \sum_{i=1}^{n} \beta j APt = j + \epsilon t \quad \text{----------} \quad (6)$$

Where: n - number of observation

M - number of lag
EPt - Edo State market price
DPt - Delta State market price
APt - Akwa-Ibom State market price
α and β - parameters to be estimated.

Error Correction Model (ECM) : The ECM was applied to investigate further on short–run interaction causality between variables and ability to correct long run deviation in the short run.

$$\Delta p_{1t} = \alpha + \Sigma \beta_1 \Delta p_{1t-k} + \delta \Delta e_{t-1} + \Sigma \beta_2 \Delta p_{2t-k} + \beta_3 \Delta p_{2t} + \varepsilon_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (8)$$

Where β_1, β_2 and 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}.
e_{t-1} - error-correction term, obtained from the co-integration equation captures the deviation from long-run equilibrium.

RESULTS AND DISCUSSIONS

Testing for stationarity: Unit Root Test Results

In order to ascertain whether the variables were stationary or not, the 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 suggests 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 prices of natural rubber in one State/market do not determine prices in another State/market cannot be rejected at $P<0.05$.

When first-differenced, however, the null hypothesis of non-stationarity was rejected in favour of the alternative as the values of the ADF t-statistics 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

Market price series	At level/first difference	ADF Test	P. Value	Remark
Edo(E)	1(0)	-1.639495	0.4596	Non-stationary
	1(1)	-9.416844	0.0000	Stationary
Delta(D)	1(0)	-1.387001	0.5869	Non-stationary
	1(1)	-9.468160	0.0000	Stationary
Akwa- Ibom(A)	1(0)	-1.409741	0.5758	Non-stationary
	1(1)	-10.46218	0.0000	Stationary

1(0) – price level and 1(1) - first differences
Source: Computed from Secondary Data, 2017

Co integration Test Results

Both Trace and Maximum Eigen value statistics indicate the existence of co-integration relationship at 5 percent significant level for natural rubber. To check the first null hypothesis that the variables were not co-integrated ($r = 0$), trace and eigenvalue statistics were calculated, results showed that the maximum eigen-value and trace test statistics values were higher than

5 per cent critical values. Therefore, the null hypothesis was rejected and the alternative accepted for one or more co-integrating vectors.

Similarly, the null hypotheses: r = 0, and r ≤ 1 from both statistics were rejected against their alternative hypotheses of r ≥ 1. The null hypothesis r ≥ 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 were well below their corresponding critical values at 5 % of significance. Both tests confirmed that all the three selected rubber producing States/markets had 2 co-integrating vectors out of 3 co-integrating equations, indicating that they were well integrated and price signals were transferred from one market to the other to ensure efficiency. Thus, Johnson co-integration test has shown that though the selected natural rubber States/markets in Nigeria were geographically remote areas and spatially segmented, they were well-connected in terms of prices of natural rubber, demonstrating that the selected States/markets during the study period were co-integrated and had long-run price linkage across them. Thus, the Edo, Delta and Akwa-Ibom States markets were co-integrated and there existed long-run equilibrium. This was supported by earlier studies carried out by Mesike, 2012 who concluded that cocoa and rubber market price within Nigeria are highly integrated; and the findings of Emokaro and Ayantoyinbo (2014) the result indicates that rice markets in Osun State were co-integrated and there existed long-run equilibrium.

Table 2: Testing for Numbers of Co-integration Relations in the Study Area

H_0	H_A	Eigen value	Critical value (5%)	Prob.**	Hypothesized No. of CE(s)
			Trace test		
r=0	r ≥1	0.277313	29.79707	0.0000	None*
r≤1	r ≥2	0.194815	15.49471	0.0001	At most 1*
r≤2	r=3	0.026684	3.841466	0.0638	At most 2
			Maximum Eigen-value test		
r=0	r ≥1	0.277313	21.13162	0.0000	None*
r≤1	r ≥2	0.194815	14.26460	0.0002	At most 1*
r≤2	r=3	0.026684	3.841466	0.0638	At most 2

Note:*denotes rejection of the null hypothesis at 5 per cent level of significance.
Source: Computed from secondary data, 2017

Short Run Co-integration Relationship

The VECM was employed in order to analyze the short-run dynamics of the effects of natural rubber prices in the selected markets, having established that a long run relationship existed between the variables. The result of the VECM show that if there is a positive deviation from the long run equilibrium the market tends to respond with a decrease or increase in the other market. The Delta State price appears to respond faster than the Edo and Akwa-Ibom price. The adjustment coefficient was statistically significant at 1 percent for Delta market price for rubber suggesting that the Edo and Akwa-Ibom price is weakly exogenous. This implies that movement in the Edo and Akwa-Ibom was less affected by price in the Delta market while movement in the Delta price was dictated by events in the Edo and Akwa-Ibom markets. This means that the long-run equilibrium in the natural rubber after an exogenous shock is restored primarily by corrections made by the Delta market prices.

The coefficient of the error correction term, which signifies the speed at which rubber price in the selected States adjust to their long run equilibrium level, was negative and statistically significant. The significant coefficient of the error correction term confirms the existence of a long-run equilibrium relationship of price for natural rubber in Nigeria. The coefficient of the error correction term of 0.325550 implies that, the feedback into the short-run dynamic process from the previous period is 32.55% and the negative sign suggests that the adjustment 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 32.55% which was relatively weak compared with the perfect adjustment of 100% threshold. It suggests that the price in Edo, Delta and Akwa-Ibom States adjust partially to its long-run level after a price rise (shock). The error correction term has important feature for determining the time period after any deviation from long run equilibrium. (Fayaz and Naresh 2014).

Table 3: Short–run Analysis using VECM

	Δ(EDO)	Δ (DELTA)	Δ(AKWA-IBOM)
CointEq1	-0.226136	-0.325550	-0.090086
	(0.17735)	(0.17028)	(0.17449)
	[-1.27508]	[-1.91189]	[-0.51629]

Source: Computed from Secondary Data, 2017 (Price series Jan. 2005 to Dec. *2015*)
Note: All figures in brackets (...) are standard errors and all figures in parenthesis [...] are t–values.

Granger Causality Tests

The F-statistic for the causality tests of prices in these markets on other markets have statistically significant. The null hypothesis of no granger causality was rejected in each market. Besides, Edo had two, Delta and Akwa-Ibom had one each values of F-statistic being statistically significant on other market prices. According to the granger causality test, there were unidirectional causalities between the market pairs: Akwa-Ibom – Delta markets, meaning that a price change in the former market in each pair granger causes the price formation in the latter market, whereas the price change in the latter market is not fed back by the price change in the former market in each pair. From Table 4, it can be seen that there exists bidirectional causality between Edo - Delta, and Edo - Akwa-Ibom market pairs as shown in Figure 1. In these cases, the former market in each pair granger- caused the price formation in the latter market which in turn provides the feedback to the former market as well. The long-run and short-run null hypotheses that rubber market prices were not integrated and a price change in a market was not immediately transmitted to other markets, respectively, is be accepted.

The results show that there existed both long-run and short-run market integrations between Edo, Delta and Akwa-Ibom State/markets. Thus, changes in the price of rubber in one market would cause the price of rubber in other markets to adjust immediately and the estimated speed of adjustment was about 32.55%.

Table 4.:Pair-Wise Granger Causality Test for Natural Rubber Market

Null Hypothesis	F	df	P - value	Granger cause	Direction
MEDO does not Granger Cause MDEL	17.45	2	0.00***	Yes	Bidirectional
MDEL does not Granger Cause MEDO	12.37	2	0.00***	Yes	
MEDO does not Granger Cause MAKW	18.26	2	0.00***	Yes	Bidirectional
MAKW does not Granger Cause MEDO	14.20	2	0.00***	Yes	
MAKW does not Granger Cause MDEL	3.00	2	0.05**	Yes	Unidirectional
MDEL does not Granger Cause MAKW	2.09	2	0.12	No	

****Significant at 1% probability level*

Source: Computed from Secondary Data, 2017

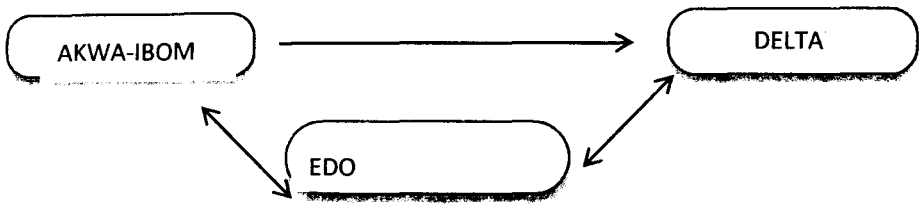

Figure 1: Granger Causality Directions between the Market Pairs
Computed from Survey Data, 2017

CONCLUSION AND RECOMMENDATIONS

The results of co-integration test have indicated that different state markets in the country are well-integrated and have long-run price association across them. The granger causality shows the direction of price formation between two markets; there were bidirectional and unidirectional causalities between the market pairs, thus, changes in the price of rubber in one market would cause the price of rubber in another State to adjust immediately. Delta State market which has been shown in this study to be the leading market should be the target for government developmental reforms. Revenue will be greatly enhanced with such incentives by government to intensify their production and marketing of natural rubber which will create greater opportunities for economic growth and development and eventually improve market efficiency and increased technical efficiency of rubber producers.

REFERENCES

Abolagba, E.O., N.C. Onyekwere, B.N. Agbonkpolor and H.Y. Umar (2010): "Determinants of agricultural exports". *Journal of Human Ecology.*, 29: 181-184.

Alufohai,G.O and Ayantoyimbo.A. A.(2014). Co-integration analysis of maize marketing in Osun State, Nigeria. *NISEB Jounal, publication of Nigerian Society for Expermental Biology,* 14(2):1-19

Central Bank of Nigeria (2012). *Statistical Bulletins and Annual Report*, 2012. Vol. 2. Dec. 2012.

Emokaro, C.O. and Ayantoyinbo, A.A. (2014). Analysis of Market Integration and Price Variation in Rice Marketing in Osun State, Nigeria. *American Journal of Experimental Agriculture,* 4(5): 601-618.

Engle, R.F. and Granger, C.W.T. (1987). "Co-integration and Error Correction Representation, Estimation and Testing. *Econometrica* 55(2) 251-276.

Engle, R.F. and Yoo, B.S. (1987). Forecasting and testing in co-integration systems. *Journal of Econometrics.* 35(3):143-159.

FAOSTAT, "Food and Agriculture Organisation Statistics, Economic and Social Department, the Statistic Division". (various issues)

Fayaz A B and Naresh S (2014) Cointegration, Causality and Impulse Response. Analysis in Major Apple Markets of India. *Agricultural Economics Research Review* Vol. 27 (2) pp 289-298

Gujarati, D.N. (2003). *Basic Econometrics.* 4th Edition. McGraw-Hill, New York. pp. 563-636

Mesike, C.S (2012). Impact of Government Agricultural Policies on Exports of Cocoa and Rubber in Nigeria. *Agricultural Tropica et Subtropica,* 45(4):184-188

RRIN (Various Edition). *Annual Report. Federal Ministry of Agriculture* Abuja – Nigeria