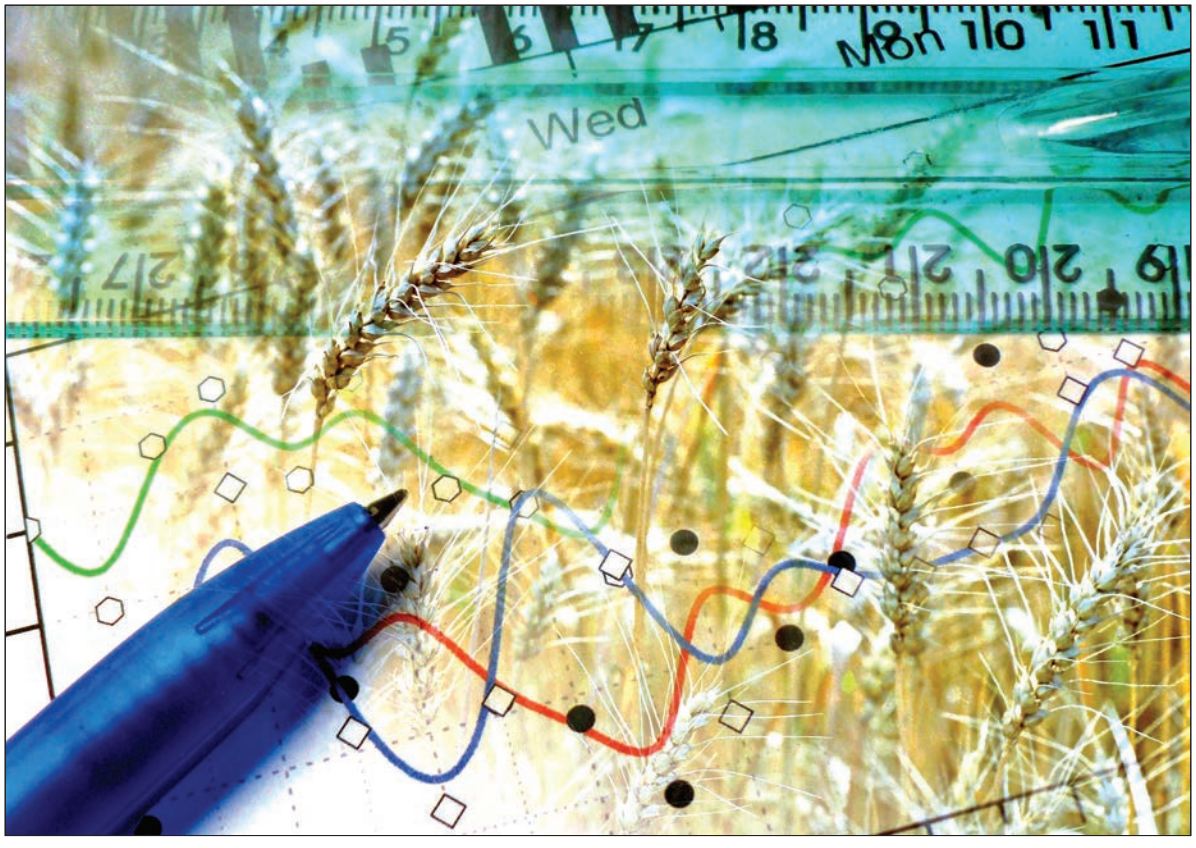

Trends in Agricultural Economics

ISSN 1994-7933

science alert

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OPEN ACCESS Trends in Agricultural Economics

ISSN 1994-7933
DOI: 10.3923/tae.2017.12.17

Research Article
Co-integration and Causality Analysis in Major Natural Rubber Markets of Nigeria

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Abstract

Background and Objective: In recent times, natural rubber prices have been on the increase but production is still on the decrease in Nigeria. Could it be that producers/marketers not taking the advantage of price transmissions between markets to improve their profit margin? This study aimed to determine the long-run and short-run rubber market price integrations and transmission between local markets in Edo, Delta and Akwa-Ibom states in South-South Nigeria. **Materials and Methods:** Three major state markets were purposively selected from South-South Nigeria namely-Edo, Delta and Akwa-Ibom States. Data for the study were collected from Average monthly retail price data (N/kg) of natural rubber, covering the period January, 2005 to December, 2015 (11 years). Data collected was analyzed using Johansen co-integration test and Granger causality by VECM. **Results:** Results 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 states, bidirectional for the other two market pairs. **Conclusion:** The granger causality shows the direction of price formation between two markets and related spatial arbitrage, 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 and the estimated speed of adjustment is about 32.55%. The significant coefficient of the error correction term showed immediate adjustment to changes in the long-run equilibrium.

Key words: Natural rubber, rubber markets, co-integration, Granger causality, price transmission

Citation: Agbonkpolor Nosa Betty, Alufohai Grace Oghenerobor, Mesike Chinye Samuel and Adindu Ashetu Grace, 2017. Co-integration and causality analysis in major natural rubber markets of Nigeria. Trends Agric. Econ., 10: 12-17.

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

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 t CBN[1], out of which about two-third of it is exported, contributing 1.3% of the world's output of natural rubber FAOSTAT[2].

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.*[3] 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. Market integration analysis will help in analyzing the rubber market performance. Market integration can be measured in terms of the strength and speed of price transmission between markets across various states of the country[4].

Previous studies in natural rubber focused mainly on its production[5-8,] constraints to production[9,10] and rubber seed processing[11]. However, very little worked on its marketing was done yet. Rubber marketing in Nigeria, was studied only by Giroh *et al.*[12], who focused on estimating costs and returns from rubber marketing and examined market structure, whereas Mesike *et al.*[13], focused on the supply response of rubber farmers to prices and other factors in Nigeria were analyzed using co-integration and vector error correction technique. But no one take a holistic economic analysis of the complete marketing system. This study fills that gap. It expanded the existing literature and the subject of market integration analysis in Nigeria and also shed light on required efforts to enhance the production and utilization of rubber at larger scale to bring about economic development in the area. The information generated will be useful to a number of organizations including: Research and development organizations, marketers, producers, processors, policy makers, government and non-governmental organizations to assess their activities and redesign their mode of operations and ultimately influence the design and implementation of policies and strategies.

This study was however, carried out to determine long-run and short-run rubber market price integrations and transmission between local markets in Edo, Delta and Akwa-Ibom states.

MATERIALS AND METHODS

Area of study: The study was conducted in three selected states in South-South Nigeria, namely Edo, Delta and Akwa-Ibom states in 2016. The State covers a land area of about 17,902 km^2 with a population of 3,218,332 (NPC[14]). Delta State presently covers a land area of about 18,050 km^2 out of which more than 60% is land with a population of 4,098,391 people (NPC[14]). Akwa-Ibom State presently covers a land area of 7,081 km^2 with a population estimate of 4,805,451 (NPC[14]). Notable food crops cultivated in the study area include: Cassava, maize, yam, cocoyam, cowpea, vegetables and cash crops such as rubber, oil palm, cocoa, kola nut, citrus, coffee, cashew and mangoes.

Data collection: Secondary data on monthly average rubber price (N/kg) in Edo, Delta and Akwa-Ibom markets from January, 2005 to December, 2015 were sourced from Rubber Research Institute of Nigeria, Edo, Delta and Akwa-Ibom states' Agricultural Development programs, the various issues of Central Bank of Nigeria (CBN) and Food and Agriculture Organization (FAO) publications.

Analytical procedure: Data were analyzed using EViews software and statistical processes were employed in order to achieve an appropriate analysis. The data collected was analyzed using co-integration, Granger causality and vector error correction model. 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 was 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 1(0) or 1(1) using the Johansen test. Alufohai and Ayantoyinbo[15], formulation test on residual from the co-integration regression was given in Eq .1.

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

where: t is time e_t is residual error term assumed to be distributed identically and independently,P_{t1}, P_{t2} and $P_{t3,}$ are rubber price series in three markets in Edo, Delta and Akwa-Ibom market states.

The null hypothesis of non-stationary could not 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 could not 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/δ/<1, thus testing for stationary is equivalent with testing for unit roots (δ <1) under the following hypotheses:

- Ho: δ = 0 the price series is non-stationary or there is existence of unit root
- H1: δ ≠ 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 Eq.1 were considered to be temporary deviation from the long run equilibrium.

$$\Delta e'_t = \gamma e'_{t-1} + \sum_{i=1}^{p} yi \Delta e'_{t-1} + \delta_t \quad (2)\ (\text{Mussema}[16])$$

Consider a pair of variables p_{t1} and p_{t2} each of which is integrated of ordered their linear relationship can be given by Eq 3[17].

$$\hat{e}_{t-1} = p_{1t-1} - \alpha - p_{2t-1} \quad (3)$$

In order to conclude that the price series were co-integrated the residuals from the equation had to follow stationarity. If the residual errors were stationary then the linear combination of the two prices is stationary (co- integrated). If the t-statistic of the coefficient did not exceed the critical value the residuals, $\hat{e}_{t-1}$ from the co-integration equation were stationary[18] and thus the price series p_{1t} and p_{2t} are co-integrated. Co-integration between time series evident that there must be an identification of a single market.

Granger causality test: This test was used to test the existence and the direction of long-run causal price relationship between the markets (Granger[19]). 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 Eq .4-6 through a bivariate VAR:

$$EP_t = \alpha 0 + \sum_{i=1}^{m} \alpha i\, DP_t = i + \sum_{i=1}^{n} \beta j EP_t = j + \varepsilon t \quad (4)$$

$$DP_t = \alpha 0 + \sum_{i=1}^{m} \alpha i\, AP_t = i + \sum_{i=1}^{n} \beta j EP_t = j + \varepsilon t \quad (5)$$

$$AP_t = \alpha 0 + \sum_{i=1}^{m} \alpha i\, EP_t = i + \sum_{i=1}^{n} \beta j EP_t = j + \varepsilon t \quad (6)$$

Where:

n = Number of observation
M = Number of lag
Ep_t = Edo State market price
Dp_t = Delta State market price
Ap_t = 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.

$$\Delta p_{1t} = \alpha + \sum \beta_1 \Delta p_{1t-k} + \delta \Delta e_{t-1} + \sum \beta_2 \Delta p_{2t-k} + \beta_3 \Delta p_{2t} + \varepsilon_t \quad (7)$$

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 DISCUSSION

Testing for stationarity: 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 were presented in Table 1. The empirical evidence suggested that price series were not stationary in their level form and any attempt to use the non-stationary variables could lead to spurious regression and such results could not be used for prediction in the long run. The null hypothesis stated that the prices of natural rubber in one state/market did not t determine prices in another state/market so it could not 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 was necessary and sufficient for a test of co-integration of the price series.

Co-integration test results: Both trace and maximum eigenvalue statistics indicate the existence of co-integration relationship at 5% 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 eigenvalue and trace test statistics values were higher than 5% critical values. Therefore, the null hypothesis was rejected and the alternative accepted for one or more co-integrating vectors (Table 2).

Similarly, the null hypotheses: $r = 0$ and $r \leq 1$ from both statistics were rejected against their alternative hypotheses of $r \geq 1$. The null hypothesis $r \geq 2$ from both tests (trace test and maximum eigenvalue test) were accepted and their alternative hypotheses ($r = 3$) were rejected as the trace value and maximum eigenvalue 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 showed 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[20], who concluded that cocoa and rubber market price within Nigeria are highly integrated and the findings of Emokaro and Ayantoyinbo[21] the result indicated that rice markets in Osun State were co-integrated and there existed long-run equilibrium.

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 showed 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

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

Table 2: Testing for numbers of co-integration relations in the study area

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

*Denotes rejection of the null hypothesis at 5 percent level of significance

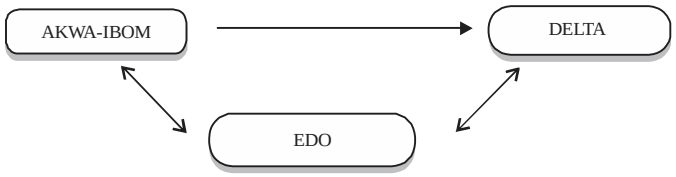

Fig. 1: Granger causality directions between the market pairs

Table 3: 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, **Significant at 5% probability level, Computed from secondary data, 2017[22]

market. The Delta State price appears to respond faster than the Edo and Akwa-Ibom price. The adjustment coefficient was statistically significant at 1% for Delta market price for rubber suggesting that the Edo and Akwa-Ibom price exogenous weakly. 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 was restored primarily by corrections made by the Delta market prices.

The coefficient of the error correction term, which signified 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 formed 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 had important feature for determining the time period after any deviation from long run equilibrium.

Granger causality test: The data in Table 3 showed unidirectional causalities between the market pairs: Akwa-Ibom-Delta markets, meaning that a price changed in the former market in each pair granger caused the price formation in the latter market, whereas the price change in the latter market is not feedback by the price change in the former market in each pair. There was also bidirectional causality between Edo-Delta and Edo-Akwa-Ibom market pairs as shown in Fig. 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, was rejected.

The results showed that there exist 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%. However, Beag and Naresh[17] found out that apple market pair-wise co-integration test confirmed that the pairs of Ahmedabad–Kolkata and Bengaluru-Kolkata markets do not have any price association between them. Moreover, Granger causality tests indicated that there was no causality direction on price formation between them.

CONCLUSION

The findings of the study found out that Delta State price appears to respond faster than the Edo and Akwa-Ibom price, changes in the price of rubber in one market would cause the price of rubber in another state to adjust immediately and that can be beneficial for agricultural policy makers and the government developmental reforms program, revenue will be

greatly enhanced with such incentives by government to intensify their production and marketing of natural rubber which create greater opportunities for economic growth and development and eventually improve market efficiency and increased technical efficiency of rubber producers.

SIGNIFICANCE STATEMENTS

The findings of the study provide relevant information in formulating policies relating to government developmental reforms program In addition, the findings will equip agricultural policy makers and extension agents in addressing the major barriers facing farmers in making decisions in rubber prices and marketing.

ACKNOWLEDGMENTS

The authors sincerely appreciate the genuine efforts of the authorities of the Rubber Research Institute of Nigeria and the tree crop units of the Ministry of Agriculture and Natural Resources in Edo, Delta and Akwa Ibom States for the support during this study.

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