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Spatial Market Integration of Rice Between India And Nigeria: A Co-integration Approach

Makama, S.A., Amruthat T. J.
Department of Agricultural Economics, UAS, Raichur, Karnataka State, India

Abstract: *The study was conducted to examine the relationship between India and Nigeria rice markets using monthly export and domestic price of rice that was converted into US$ using the real effective exchange rate for a period of ten years. The result of co-integration analysis depicts that there is a presence of long run relationship between India and Nigeria rice markets. Domestic price of rice in Nigeria influence the export price of India rice in the long run. However, the coefficient of the speed of adjustment between India and Nigeria was -0.903, indicating that adjustment process is relatively fast with around 90 per cent of divergence from the long-run equilibrium been corrected in each one to six month. However, findings of this study showed that there is no short run causality running from Nigeria rice market to that of India. Also, the result of the Granger causality test showed that there is bidirectional causation; Nigeria market Granger cause India and India market Granger cause Nigeria.*

Key words: *Spatial, Rice, Integration, India, Nigeria*

I. Introduction

Agriculture with its allied sectors, is unquestionably the largest livelihood provider in India, more so in the vast rural areas. It also contributes a significant figure to the Gross Domestic Product (GDP). Sustainable agriculture in terms of food security, rural employment, and environmentally sustainable technologies such as soil conservation, natural resource management and biodiversity protection are essential for holistic rural development. Indian agriculture and allied activities have witnessed a green revolution, white revolution, yellow revolution and blue revolution (www.india.gov.in, 2014). Around 70 per cent of the Indian population earns their livelihood from agriculture.

India produced 157 million tonnes of rice in 2010-11 and the production is reported to have reached up to 159 million tonnes in 2013-14. Performance of area, yield and production of rice in India during the last three decades showed deceleration in the growth rate of yield for rice. With the rice area growth not compensating for the deceleration in yield growth, the growth rate of rice production has came down to 1.51 percent per year during 2000-01 to 2010-11, from 3.62 percent per year in the 1980s. India lifted the ban on exports of non-basmati rice in 1994. In 2001, it started conceding subsidies on non-basmati rice exports, which propeled the country as the second largest exporter in 2002 and 2003 a position which it retains up to 2014 (FAO, 2014)[1]. Recently, the country becomes the world largest exporter of non basmati rice (FAO, 15)[2].

On the other hand, Agriculture is the backbone of the Nigerian economy before the discovery of oil in 1970s, up till the late 1980's it contributed around 70 per cent of the country's Gross Domestic Product. However, the Agricultural sector still occupies a central position in the lives of Nigerian populace as majority of them depend on it as a means of livelihood. The sector was the major source of foreign exchange earnings and employs about 70 per cent of the rural working population (Makama, *et al* 2011)[3]. However, after the discovery of crude oil in the early 1970s, there has been a declining performance of the sector in spite of its potentials.

Agricultural sector still remains the major source of food and raw materials for the teeming population and domestic industries and had sustained the growth of the Nigerian economy for decades. Moreover, Nigerian agriculture is characterized by small scale farm, low farm income, low level of capacity and primitive techniques of production (Obadun, 1998)[4]. While it is widely recognized that, the development of agriculture is one of the crucial requirement for overall economic growth, there is little consensus with respect to most appropriate strategy for securing increase farm output and productivity in developing agriculture. However, as a result of the seasonal nature of production, government opted to embark upon various strategies that aimed at ensuring continues production of crops (Makama, *et al* 2011)[3].

Nigeria lifted its rice import ban in 1994 and imposes *ad-valorem* tariffs. Since then, these tariffs have varied from 50 to 100 per cent. However, the country imposes minimum import prices for tariff calculation purposes in 2004, depending on the product origin (FAO, 2004)[5].

A well developed market for agricultural products in the third world countries provide access for the products to consumers who depend on the market for their food supply and to farmers who shift from subsistence to market oriented production. Therefore, an effective marketing system would ensure that products are available for consumption at the right quantities and quality.

India is among the five world's exporter of rice exporting over 4 million MT at Rs. 948,281 (US$ 15,546) while Nigeria which is among the five world's largest importers of Rice, imports 813,198.44 MT valuing to Rs. 184,742 (US$ 3,029) from India in the year 2012/2013 (www.agrixchange.org, 2014). This means that, Nigeria is importing about 19.5% of the total export from India.

It is therefore based on this, that the paper tried to find out the relationship between India and Nigeria rice markets thereby assessing the spatial market integration of rice between the two countries.

II. Review of Literature

Various approaches used in testing market integration includes; correlation analysis, dynamic multiplier and co-integration analysis have been used by many researchers to determine the integration of agricultural produce markets and these were reviewed as follows:

Abdu (2006)[6] used correlation coefficient as a measure of soybean markets integration at wholesale and retail levels. His results of correlation analysis revealed that all the markets were integrated at wholesale level, however there exist non-significant integration between Gboko and Jagindi markets. This means that, there exists a high level of integration of soybean markets at wholesale level. However for all other integration there exist significant correlations at one level or the other. The low level of integration of the markets at retail level may likely be due to low level of information flow about prices and high transportation cost as the markets are spatially separated.

Fossati, et al (2007)[7] in their study on Regional and International Market Integration of a Small Open Economy used Co-integration method and the results of the co-integration analysis identify different patterns of long-run market integration in the commodity markets considered. Specifically, in the case of sorghum and maize, the three markets considered are found to be spatially integrated. In the case of wheat, evidence of perfect market integration between the regional and international markets was found, however, no evidence was found of spatial market integration between the Uruguayan market and the regional or international markets.

Saran and Gangwar (2008)[8] in their study on Analysis of Spatial Co-integration amongst major wholesale egg markets in India used the co-integration test procedure to analyse the egg price series for major wholesale egg markets in the country. Their study indicated that the major markets were co-integrated apparently due to performance of market intelligence functions. The high degree of co-integration amongst various markets indicated that, the markets were competitive and efficient at the wholesale levels.

Kariuki (2011)[9] in his study on Analysis of Market Performance: A case of '*omena*' fish in selected outlets in Kenya used Co-integration analysis to check for the relationship among prices in different locations. Results of his analysis revealed that; except for Kisumu– Nairobi markets which exhibited co-integration, all the other markets were not integrated and therefore a long run relationship amongst prices existed.

Ajjan, et al (2013)[10] in their study on Integration of Chick Pea (*Cicer arietinum*) markets in India, analyzes the markets integration using monthly modal prices of Chana in six regional markets of Andhra Pradesh, Tamil Nadu, Maharastra, Rajasthan, Karnataka and Gujarat. Where for each market seasonal index, ADF text, Johansen's Co-integration and pair wise Granger causality test were carried out. Their results showed that the markets have price linkages and therefore are integrated.

Paul, *et al* (2015)[11] in their study on "Examining export volatility, Structural breaks in price volatiity and linkages between Domestic and Export prices of Onion in India" used co-integaration and Granger causality test to investigate the short and long run relationships between onion export and domestic price. Their result showed that prices in all the market share stable long run relationship. Also, the Granger causality test revealed that all the major domestic markets of Onion Granger cause export prices on one hand and export prices Granger cause prices in some of the domestic markets they considered.

Wani, *et al* (2015)[12] in their study of Market Integration and Price Forecasting of Apple in India employed co-integration analysis to explore the degree of market integration. Their findings revealed that the selected Apple markets are strongly co-integrated and converge on the long run equilibrium. It further suggests that even if there is geographical dispersion of markets, the prices are linked together indicating that all the market locations are in the same economic market system.

III. Methodology

The study relied mainly on secondary data compiled from various published sources. Monthly price data for a period from 2004 – 2014 were sourced from various sources such as FAO, World Rice statistics, World bank, NAERLS, AIREA and NBS among others and were converted into United States Dollar ($) using the real effective exchange rate. A necessary condition for integration however is that: the data series for each variable involved exhibit similar properties that is to say; is integrated to the same order with evidence of some linear combination of integrated series (Tambi, 1999)[13].

To analyze the relationship between prices, the following steps were under taken:

Unit Root Test:

A variable is integrated of order I (1) when it is stationary in level form. Stationary is defined as the process in which neither the variance of the current disturbance εt nor the autocorrelation between a current disturbance εt and one period lagged disturbance εt-1 depend on t. Order of integration is the number of times the series need to be differenced before transforming it into stationary series. Stationary series Pt, for example has a mean, variance and autocorrelation that is constant overtime. However, most economic series tend to exhibit non-stationary stochastic process of the form:

$$\boldsymbol{P_t = \alpha + \beta P_{t-1} + \varepsilon_t} \qquad (\mathbf{1})$$

Where α is a constant drift, ß = 1 and ε_t is an error term, If ε_t has zero mean, constant variance and zero covariance, then P_t is a random walk and is said to be integrated of order I (1). The series Pt is integrated because it is the sum of its base value Po and the difference in P up to time t. Since ß is unity, P is said to have "Unit Root". If Pt is non-stationary, the variances may become infinite and any stochastic shock may not return to a proper mean level. As shown by Engle and Granger (1987), such a non-stationary series has no error-correction representation. A non-stationary series requires differencing to become stationary.

Pt is integrated of order (Dx), or Pt ~ I (Dx), if it is differenced Dx times to achieve stationary. Engle and Granger (1987) provide appropriate test for stationary of individual series as the Dickey-Fuller (DF) and Augmented Dickey-Fuller (ADF) statistics, which used OLS regression. ADF test allows for more dynamics in the regression than DF.

$$\Delta P_t = -\beta_i P_{t-1} + \sum T \qquad (2)$$

$$t = 1\Delta P_{t-1} + \varepsilon_i \qquad (3)$$

Where

T is time selected so that Σt is white noise. The t-statistics for ß is the

ADF statistics

Ho = Pt ~ I (1) Vs H1 = Pt~ I (0) (4)

Ho is rejected if ß is significantly different from zero i.e. greater than the critical t-value then the series is stationary. If the Ho: cannot be rejected then (Pt) cannot be stationary and it may be I (1) or (2), then the test is repeated with the second difference,

$$\Delta 2P_t = -\beta P_{t-1} + \sum T \qquad (5)$$

$$t = 1\Delta 2P_{t-1} + \varepsilon_i \qquad (6)$$

Where

Δ2 = almost the second difference.

The ADF therefore tests the following hypothesis:

Ho: Pt ~ I (2) Vs H1: ~ I (1) (7)

If Ho hypothesis is rejected, then the series is stationary .If not the test is repeated with the third difference until it becomes stationary.

2- **Co-integration Test***:*

If the series to be investigated are both integrated of the same order of integration, that is have similar basic statistical properties, then the next stage would be to investigate whether they are co-integrated with each other. The first procedure is to run OLS regression (co-integration).

a) $P_t = a_1 + \beta_1 R_t + \mu_t$ (8)

β_1 = the slope coefficient estimates from the OLS regression of the dependent price (P) on a constant and on a price regarded as the reference price (R). Also β_2 can be calculated from OLS regression of reference price (R) on a constant and local price (P) as follows:

$$R_t = a_2 + \beta_2 P_t + Z_t \qquad (9)$$

b) Secondly the residual (μ_t) from cointegration regression should be tested for stationarity.

$$\Delta\mu_t = -\beta_i \Delta\mu_{t-1} + \sum T_i = 1\theta_i \Delta\mu_{t-1} + V_t \qquad (10)$$

and an ADF test is carried out on the residuals to investigate whether the calculated ADF statistics are large and negative enough to reject the null hypothesis of integration of order (1) as:

Ho: μ_t ~ I (1) Vs H1 ~ 1(0) (11)

If the ADF statistics result from the second equation is not large and negative than the critical t-value, then it is likely that the coefficients $ß_1$ and $ß_2$ do not exist and the series are not co-integrated.

3**- Dynamic Model (Reduced Form) Test:**

A dynamic model with an error correction form is the third test. The theorem states that, if a set of variable is co-integrated of order I (1), then there exists a valid error correction representation of the data. The converse of this theory also holds, namely if a set of variables are of order I (1) and generated by an error correction model (ECM) then this set of variables are necessary co-integrated. So the error correction model is used in conjunction with the autoregressive distributed lag model (ADL) as follows:

ADL Model: $P_t = a_i P_{t-1} + \beta_{i0} R_t + \beta_1 R_{t-1} + \varepsilon$ (12)

ECM Model: $\Delta P_t = (a_{i-1}) P_{t-1} + \beta_{i0} \Delta R_t + (\beta_{i0} + \beta_{i1}) R_{t-1}$ (13)

This after some rearrangement, gives;

$$\Delta P_t = \beta_0 \Delta R_t + (a_{i-1})(P_{t-1} - K R_{t-1}) + \varepsilon \quad (14)$$

Where K = $(\beta_0 + \beta_1)$ (1-a)

K is thus the long run or equilibrium solution of the dynamic model. The model captures the short-run effect of R through ßo, and long run equilibrium effect through K and feeds back, or error correction effect, through (1-a). The model can also be represented as follows:

$$\Delta P_t = \emptyset_{11} \Delta P_{t-1} + \dots + \emptyset_{1n} \Delta P_{t-n} + \emptyset_{21} \Delta R_{t-1} + \cdots \emptyset_{2n} \Delta R_{t-n} + \beta_1 P_{t-1} + \beta_2 R_{t-1} + \varepsilon_{1t} \quad (15)$$

and

$$\Delta R_t = \emptyset_{31} \Delta P_{t-1} + \cdots + \emptyset_{3n} \Delta P_{t-n} + \emptyset_{41} \Delta R_{t-1} + \dots + \emptyset_{4n} \Delta R_{t-n} + \beta_3 P_{t-1} + \beta_4 R_{t-1} + \varepsilon_{2t} \quad (16)$$

Where equation (15)

$\Delta P_t = P_t - P_{t-1}$ = difference in prices in logarithm form in period t and previous period for local market.

ΔP_{t-1} and ΔR_{t-1} = differences in prices in logarithm form in period $t-1$ and previous period $t-2$ for local and reference markets respectively.

ΔP_{t-n} and ΔR_{t-n} = differences in prices in logarithm form in period t-n and previous period (t-n-1) for local and reference market, respectively.

P_{t-1} and R_{t-1} = represent prices in logarithm form for previous period $(t-1)$ in local and reference market, respectively.

$\emptyset_{11} \dots \emptyset_{1n}$ = regression coefficient for local market prices from period t-1 to t-n.

$\emptyset_{21}$ ... $\emptyset_{2n}$ = regression coefficient for reference market prices from period $(t-1)$ to $(t-n)$.

β_1 ... β_2 = regression coefficient of Pt-1 and Rt-1, respectively.

ε_{1t} and ε_{2t} = Error term for equation (15) and (16), respectively.

Where equation (16):

$\Delta R_t = R_t - R_{t-1}$ = Reference market differences in prices in logarithm form in period (t) and previous period.

$\emptyset_{31}$........ $\emptyset_{3n}$ = Local market prices regression coefficient from period $(t-1)$ to $(t-n)$.

β_3..... β_4 = Regression coefficients of P_{t-1} and R_{t-1} respectively.

Causality And Exogeneity:

A- Causality:

There is strong connection between co-integration and causality in that at least one Granger causal relationship must exist in co-integrated system (Alexander and Wyeth, 1994)[14]. The word causality defined by Alexander and Wyeth, (1994) to reflect the fact that price changes in the location towards which causation moves occur both after, and in away, which relates to price changes in the location from which the causation comes.

If two price series are integrated and they are co-integrated of order (1) there has to be some causality in one direction or the other between price series. Causality is calculated by using auto-regressive distributed lag model (ADL). The causality runs from the independent variable to the location towards which causation moves, if occur after the price changes in the location which is the origin of the causation and moves in the same direction (Idris, 2002)[23].

$$\Delta P_t = \beta_{11} \Delta P_{t-1} + \cdots + \beta_{1n} \Delta P_{t-n} + \beta_{21} \Delta R_{t-1} + \cdots + \beta_{2n} \Delta R_{t-n} + \varepsilon_{it} \quad (17) \text{ and}$$

$$\Delta R_t = \beta_{31} \Delta P_{t-1} + \cdots + \beta_{3n} \Delta P_{t-n} + \beta_{42} \Delta R_{t-1} + \beta_{4n} \Delta R_{t-n} + \varepsilon_{it} \quad (18)$$

All coefficients as defined in the previous equation (i.e. eqn. 15 and 16)

F-statistics to testing (Granger-Causality) is given, for which the null of no Granger-Causality is:

Ho = ß21=...= ß2n = 0

Calculated F-statistics is compared to critical F-value, and rejection of null hypothesis implies causality from (R) to (P) because lagged reference price R provides a better prediction of current changes in local prices. Similarly rejecting the following null hypothesis

Ho = ß31 = ... = ß3n = 0 indicates causality from (P) to (R).

B- Exogeneity:

Wyeth (1992)[15] stated two levels of exogeneity could be defined, 1- Week exogeneity, which is inferred when the disequilibrium terms P_{t-1} and R_{t-1} are not significant in the error correction model (reduced form) and, 2- Strong exogeneity when there is also no significant Granger causality from the independent variable.

Exogeneity is used to test the validity of error correction model (structural form), which results in rejection, or acceptance of short run integration.

C- Short Run Integration:

Checking for exogeneity in order to assess the validity of structural form has one advantage over the reduced form (measuring short-run integration (Wyeth, 1992) [15].

The structural equation can be written as:

$$\Delta P_t = \beta_{11}P_{t-1} + \beta_{12}P_{t-2} + \beta_{20}\Delta R_t + \beta_{21}\Delta R_{t-1} + \beta_{22}\Delta R_{t-2} + \beta_1 P_{t-1} + \beta_2 R_{t-1} + \varepsilon_t \quad (19)$$

The structural equation can be used to measure short-run integration between the two markets, since the short-run integration can be obtained by the coefficient of (ΔR_t) and (R_{t-1}) equal unity and the coefficient on P_{t-1} equal (-1). The weak form of short run integration can be inferred where $\Delta R_{tt} = 1$ and the sum of the coefficients of disequilibrium terms (P_{t-1}+R_{t-1}) is equal to zero.

IV. Results and Discussion

Due to the sensitivity of time series to lag length, a selection criterion was adopted to determine the number of lags to be included in the model. Selection criteria serve as a guide and hence, the lag that best suits actual price changes were tested. Akaike Information Criteria (AIC) was chosen over SC and HQ even though they all suggested for same lag six but the AIC however has the minimum value among them, thus lag 6 was used throughout the con-integration analysis. Thus, for the two markets pairs and the rice prices, one to six (1 to 6) lag order was chosen. This means that rice prices are expected to significantly change within one to six months period in the market under study.

For price series to be co-integrated, they must be stationary at the same order. Thus, an Augmented Dickey Fuller (ADF) test was applied at level and first difference to check the stationarity in price series. Results of the ADF test showed that in both Nigeria and India, ADF values were higher than the critical values at 5 per cent level, indicating the existence of unit root in the series and therefore implying the non-stationary nature of the data at level. However, at first difference the ADF values were less the critical values at 5 per cent level of significance, suggesting the series were free from the consequences of unit root. This implied that price series turned out to become stationary at first difference. This means that the domestic and export price series of Nigeria and India respectively are integrated of order one I(1), when linear trend is excluded from the unit root test (table 1). It also explains the long-run equilibrium relationship in rice markets.

Table 1: ADF Unit Root Test on Monthly Prices of Rice Markets (India and Nigeria)

Country	At Level	At First Difference	Critical Values (5%level)
Nigeria	-2. 002	-11.158	-2.884
India	-1. 786	-12.877	-2.884

Results of the co-integration test between India and Nigeria rice markets depicted that there existed at least one co-integrating vector between India and Nigeria rice markets at 5 per cent level of significance (table 2).

Table 2: Co-integration Test between Export price of India and domestic price of Nigeria

H_0: r=0	H_1: r>1	Eigen value	Trace Statistics	Max-Eigen Statistics	Critical Value @5%
0	0	0.1795	28.1456*	24.7348*	15.4947
1	1	0.0269	3.4107	3.4107	3.8415

* Denote rejection of Null Hypothesis at 5% level

Results of the Vector Error Correction Model (table 3) showed that the speed of adjustment (δ) was found to be negative and significant at 1 per cent level of significance. This implied that there is a long run causality running from Nigeria to India. That is to say, there is a long run equillibrium relationship between India and Nigeria rice markets. In other words, rice prices in Nigeria influence the export price of India rice in the long run. This may be due to the fact that Nigeria is one of the major export destination of Indian rice (non-basmati). This could be true looking at the fact that Nigeria alone imported about 19.5 per cent of the total non-basmati rice exported by India during the year 2013. The negativity of the coefficient of the speed of adjustment for the two pairs of markets in the table (table 3) implied that domestic prices of Nigeria and the export price of India markets tend to converge in the long-run. The coefficient of the speed of adjustment between India and Nigeria was found to be -0.903, which indicates that adjustment process is relatively fast with around 90 per cent of divergence from the long-run equilibrium being corrected in each one to six month. However, findings of this study showed that there is no short run causality running from Nigerian Rice market to that of India (table 4).

Table 3: Estimates of Vector Error Correction Model on Export price of India and Domestic price of Nigeria

Coeefitients	C	δ	$ß_1$	$ß_2$	$ß_3$	$ß_4$	$ß_5$	$ß_6$
Coeefitients Value	3.309	-0.903**	-0.149	-0.116	-0.081	-0.012	-0.066	-0.033
St. Error	2.982	0.216	0.097	0.091	0.076	0.075	0.079	0.069
P-Value	0.269	0.0001	0.128	0.206	0.291	0.875	0.408	0.631

R^2 = 0.7613, R^2 adjusted = 0.7334, F-Stat = 27.2373, Prob.(F-Stat) = 0.0000 ** Significant at 99% level, C = Intercept, δ = Speed of adjustment and $ß_{1...}$ $ß_6$ = lag orders.

Table 4: Wald Statistic (Short run causality test)

Test Stat	Value	DF	Prob
F-Stat	0.6976	(6,111)	0.6521
Chi-Sqr	4.1853	6	0.6516
Null Hypothesis: C(8)=C(9)=C(10)=C(11)=C(12)=C(13) = 0 Null Hypothesis Summary			

The co-integration tests carried out indicated the existence of only long run relationship between India and Nigerian rice markets. The direction of the relationship between the Nigeria and Indian price series is of high importance to which Granger causality test was carried out. The Granger causality tests helps in establishing the direction of causation between the variables (in this case; the Export price of India and Domestic price of Nigeria). In this study, optimum lag length was selected based on Akaike Information Criteria (AIC) as earlier mentioned. Null hypothesis tested were; Nigeria does not Granger cause India and also India does not Granger cause Nigeria.

Result of the Granger causality test depicted that, p-values of the first null hypotheses was less than 5 per cent and therefore we rejected the two null hypothesis and accept the alternate hypothesis which says that Nigeria Granger cause India and India Granger cause Nigeria (table 5). This means that, there is a bidirectional influence on the price of India and Nigeria. This implied that rice prices adjust in between the India and Nigeria markets according to the demand and supply. For instance, increase in supply of non-basmati rice from India would cause a change in the domestic price of rice in Nigeria, so also increase in the production or rather supply of domestic rice would cause some changes to the price of Indian rice.

Table 5: Pair wise Granger Causality test between India and Nigeria

Null Hypothesis	Lags	F-Statistics	P-Value
Nigeria does not Granger cause India	6	3.361	0.004
India does not Granger cause Nigeria	6	8.199	0.000

V. Conclution

This paper investigated the long-run and short run relationship between export price Indian rice (non basmati) and domestic price of Nigerian rice. The ADF test suggested that export price and domestic price series are integrated of order one. The Johansen cointegration test has established the long- run relationship between the export and domestic price of India and Nigeria respectively. Granger causality test has revealed a bidirectional causality between the two countries. And error correction model confirmed that the domestic price of Nigeria have a long term relationship with export price of India.

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