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SPATIAL INTEGRATION AND PRICE FORMATION OF COWPEA MARKETS IN SOUTHWEST NIGERIA

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ABSTRACT

This study examined the Cointegrated Analysis of spatial price formation of cowpea markets in Southwestern Nigeria. Specifically, the study examined the statistical properties of the price series and determined the direction of causality rural and urban markets prices and examined the degree and speed of price transmission between rural and urban cowpea markets. Time series data of retail rural and urban market price of cowpea from 2004 to 2013 were obtained from Agricultural Development Programmes of Lagos, Ogun and Oyo States of Nigeria. The degree of price transmission was analyzed within the framework of Vector Error Correction Model. Stationarity of the series were tested by Augmented Dickey Fuller unit root test method while co-integration among the price series were tested by Johansen test method. In addition, Granger causality test was employed to establish the direction of causality among the price series. The ADF tests revealed that the price series were stationary at first difference. Johansen co-integration results showed that even though one co-integrating equation exists between linear combinations of cowpea price series, some stable long run equilibrium relationships exist among the price series which could be given some error correction representations. Results based on pairwise granger causality revealed that Rural Price of Maize in Oyo State have strong exogeneity over other rural and urban markets. The speed of adjustment of 51%, 87% and 60% from the short run to the long run equilibrium is relatively high as compared to a perfect adjustment of 100% threshold. This showed that there is a strong integration among the cowpea markets in Southwest Nigeria.

Keywords: spatially co-integrated analysis, price formation, cowpea markets

INTRODUCTION

The geographical separation of agricultural markets and the extent of spatial market integration have become very important to policy makers in Nigeria. Spatial market integration contributes to efficiency of the markets. Ghafoor *et. al*. (2009) defined spatial market integration as co-movement or the long-run relationship among prices and thus, the smooth transmission of price signals and information across spatially separated markets. Prices in spatially integrated markets are determined simultaneously in various locations, and information on any change in price in one market is transmitted to the other markets (Gonzalez-River and Helfand, 2001). According to Faminow and Benson (1990), spatial market integration of agricultural markets has been used as an indirect measure of market efficiency. Spatial markets are of special importance in agriculture, as often, agricultural products are bulky and/ or perishable, and the place of consumption may be different from that of production, implying possibly expensive transport costs (Sexton *et al.*, 1991). Apart from the role market integration play in the optimization of resource use, output management, increase in farm incomes, widening of markets, growth of agro-based industries, addition to national income through value addition, and employment creation, it ensures that accurate price signals are communicated to both consumers and producers for efficient product movement in addition to competitiveness, effective arbitrage and the efficiency of pricing. Lohano *et al*. (2005) stated that market integration of agricultural products has retained importance in developing countries due to its potential application to policy-making. They noted that information on the extent of market integration can be used by government to formulate policies that will prevent exploitation of the markets.

Cowpea is one of the most economically and nutritionally important indigenous African grain legumes produced throughout the tropical and subtropical areas of the world. Nigeria is the world largest producer and consumer of cowpea accounting for 45 per cent of the world's cowpea production. Cowpea can improve the productivity of cereal crops by increasing the amount of nitrogen available for uptake. In Nigeria, the average grain yield of cowpea ranges between 0.13 t/ha and 0.5 t/ha where it is widely cultivated by intercropping with sorghum, millet and maize in northern part of Nigeria. The largest market for cowpea can be found in Southwestern part of Nigeria where it is prominent in the diet of the people. Cowpea provides protein to rural and urban dwellers as a substitute for animal protein (Oyelade and Anwanane, 2013).

The major cowpea markets in Southwest Nigeria are managed by middlemen. In this study an attempt was made to find out whether cowpea markets in the State are integrated to bring about efficiency in the marketing system. Spatial price relationship has been widely used to indicate overall market performance. In order to achieve the foregoing the specific objectives were to (i) investigate the order of integration of the retail prices (ii) determine the extent of co integration between the prices and (iii) analyse the price transmission process using the Vector Error Correction Model. The rest of the paper is organised as follows: materials and methods, results and discussion and conclusion.

Materials and methods

This section introduces the data used in the study, presents the Augmented Dickey-Fuller unit root test, the Johansen's multiple co-integration test, Vector Error Correction Model as well as analysis of granger causality.

Study area

The study was conducted in southwest Nigeria which comprises of six States namely: Lagos, Oyo and Ogun States. The region is situated mainly in the tropical rainforest zone with swampy forest in the coastal regions of Lagos, Ogun and Ondo States. The agricultural sector forms the basis of the overall development thrust of the zone. The zone covers an area ranging from swamp forest to western uplands. In between are rainforests and deciduous forest and the northern parts of Oyo and Ogun States having derived Guinea Savannah Vegetation. The areas lie between latitudes 5^0 and 9^0 North and Longitudes 2^0 and 8^0 East of the Greenwich meridian. It is bounded by the Atlantic Ocean in the South Kwara and Kogi States in the north Edo State in the south and Republic of Benin in the west. It has a land area of about 114,270/km^2 representing 12 per cent of the country total arable land. Ogun State has enormous industrial potentials. Its natural resources, manpower and geographical proximity to Lagos and Oyo State make it a potential industrial zone to the nation.

Study Data

Secondary data was used for this study. This include the use of time series data of monthly retail rural and urban market prices of cowpea at ₦/kg between 2004 and 2013 obtained from the State's Agricultural Development Programmes (LASADA, OYSADEP and OGADEP). Rural markets in Lagos, Ogun and Oyo States and urban market in Lagos State were selected for the study. However, Urban Cowpea market in Lagos State was selected as the reference market, because it is assumed to be the most terminal market in Southwest Nigeria.

Model Specification

It is assumed for this study that urban prices of cowpea in Lagos State are determined principally by their rural prices, the rural price in the neighbouring States (Ogun and Oyo). The economic model for this study is specified in double logarithmic form as follows:

$$InP_{it}^{U} = \beta_0 + \beta_1 InP_{it}^{r} + \beta_2 InP_{it}^{n} + \varepsilon_i \qquad (1)$$

P_{it}^{u} = log of urban price of cowpea in Lagos State (₦/kg)

P_{it}^{r}= log of rural price of cowpea in Lagos State (₦/kg)

P_{it}^{n}= log of rural price (neighbouring State) ₦/kg

Analytical Techniques

Stationarity

Testing for stationarity and co-integration is an approach to time-series analysis designed to avoid the presence of the spurious regression problem. Stationarity tests are applied to individual time series in order to detect whether they have finite variances and a tendency to return to the mean (Behura and Pradhan, 1998).

In analysing any time series variable, testing for stationarity is a precondition since econometric relation between the time series has the presence of trend components (Davidson and Mackinnon, 1993). This involves testing for stationarity using tests such as Dickey-Fuller (DF) test, Augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1979). If one identifies the series to be non stationary, the first difference of the series is tested for stationarity to determine the order of integration. The number of times (d) a series is differenced to make it stationary is termed as the order of integration, I (d). In this study, the ADF test was used to determine the data properties due to its common application in the time series literature. The ADF test as mentioned considers the null hypothesis that a given series is non stationary. The test is applied by running a regression of the following form:

$$\Delta P_{it} = \partial P_{t-1} + \sum \beta_i \Delta P_{t-1} + \varepsilon_{it} \quad (2)$$

If the coefficient is statistically different from zero, then the series does not have a unit root and therefore is stationary. The price series were tested for stationarity as in the equation above where Pi denote price series of the cowpea markets and i= 1, 2 ..., 3 (1-Lagos; 2-Ogun; 3-Oyo). After establishing that the price series are non stationary, Johansen's co integration method was used to determine whether the system of equations is co-integrated.

Johansen's Maximum Likelihood Co-integration Test

If a linear combination of two non-stationary series is stationary, then the two series are said to be co-integrated. The ADF test for stationarity is usually supplemented by Johansen and Juselius maximum likelihood method. Maximum likelihood tests are applied to derive test statistic for the hypothesis of a given number of co-integration vectors. The specific linear combinations to be tested are the residuals from a static co-integrating regression as:

$$\Delta P_{it} = \alpha + \sum \Gamma_k \Delta P_{t-k} + \prod P_{t-1} + \varepsilon_t (3)$$

Vector Error correction Model

An Error Correction Model (ECM) is an efficient way of combining the long run co integrating relationship between the levels variables and the short run relationship between the first differences of the variables. The procedure of differencing results in the loss of valuable long run information in the data and so an error correction term is introduced in the theory of co integration to link the short run dynamics of the series with its long run value. The residuals obtained from the equation are introduced as explanatory variables into the system of variables in levels. The error correction term captures the adjustment towards long run equilibrium. Engle and Granger (1987) stated that if variables are found to be co integrated, then there existed a corresponding error correction representation which implied that changes in the dependent variables are a function of the level of disequilibrium in the co integrating relationship as well as changes in other variables. An error correction model is specified to relate the changes in the dependent variable to the independent variable as well as the error correction term where the error correction term measures the deviation from the long run equilibrium. A simple VECM that captures the interactions between urban prices and determinant variables takes the form as stated by Minot (2010) as follows:

$$\Delta P_t^u = \alpha + \theta\left(P_{(t-1)}^r - \beta P_{(t-1)}^u\right) + \delta \Delta P_{(t-1)}^u + \rho \Delta P_{(t-1)}^r + \varepsilon_t \quad (4)$$

Where:

P_t^u = log of urban price

P_t^r = log of rural price of hypothesized determinants

Δ = difference operator, so $\Delta P_t = P_t - P_{t-1}$

θ, β and δ = estimated parameters, and

εt = error term

Table 1: ADF Unit Root Tests on the Monthly Price Series

Series	Test at level 1(0)			Test at First Difference 1(1)		
Series/States	**Lagos**	**Oyo**	**Ogun**	**Lagos**	**Oyo**	**Ogun**
Rural	-2.46	-1.63	-1.44	-13.09**	-8.86**	-10.69**
Urban	-2.33	-2.39	-1.72	-12.57**	-9.93**	-10.67**

Source: Data analysis 2014

*** denote rejection of the null hypothesis at 5% significance level. The respective critical values at the 1%, 5% and 10% significance levels are -3.49, -2.89 and -2.57 for the ADF test*

Results and discussion

Test of Stationarity in the Price Series

A unit roots analysis of each of the time series of variables was used to ascertain the order of integration of the price series. This is to ensure that the variables are integrated in the same order. The results presented in Table 1, indicate that the price series were stationary at first difference 1(1). This result implied that inclusion of first differences as variables in the model, instead of normal price series, will eliminate the stochastic trend to which the nominal series are exposed.

Table 2: Results of Co-integration Tests

Series	No. of Lags	Hypothesized No. of Co-integrating equations (CEs)	Trace Test		Hypothesized No. of co-integrating equations (CEs)	Maximum Eigen Test	
			Statistics	Critical value P(<0.05)		Statistics	Critical value (p<0.05)
Cowpea	2	None**	123.15437	88.80380	None**	47.72198	38.33101
		At most 1**	75.43230	63.87610	At most 1**	35.35321	25.82321
		At most 2	13.96648	25.87211	At most 2	9.46192	19.38701
		At most 3	4.50456	12.51798	At most 3	4.50456	11.51798

Source: Data analysis, 2014

Test of co-integration among Price series

The Johansen co-integration test indicated one co-integrating vector at 5% level of significance as shown in Table 2. This result showed that the rural and urban market prices of cowpea in Southwest Nigeria are integrated. Although the price changes may vary in the short run between the different markets, they are expected to move together as a system in the long run. This result gave the opportunity to estimate the movement of prices in the long and short run, using a vector error correction mechanism.

Long and Short Run Price Integration in Selected Markets

The estimated long run relationship (t-ratio in parentheses), based on normalization in respect of the Urban prices of maize in Lagos State and their hypothesized determinants is expressed below:

$$
\begin{aligned}
InUPCLS_t = {} & 5.97 + \underset{(3.04)^{***}}{2.92InRPCLS_{t-1}} \\
& - \underset{(-2.21)^{**}}{0.08InRPCOGS_{t-1}} \\
& + \underset{(4.10)^{***}}{0.24InRPCOYS_{t-1}} \qquad (5)
\end{aligned}
$$

Co-integrating equation in (5) revealed that Rural Price of Cowpea in Lagos (RPCLS) and Oyo States (RPCOYS) exert a significant ($p<0.01$) and positive influence on Urban Price of Cowpea in Lagos State (UPCLS) while RPCOGS exert a negative influence on UPCLS at $p<0.05$. This implies that 1% increase in RPCLS and RPCOYS result to an increase in UPCLS by 2.92 and 0.24% while 1% increase in RPCLOGS result to a decrease in UPCLS by 0.08% in the long run. The estimated elasticity of -0.081 implies that a 1% price shock that raises RPCLOGS will cause a 0.08% downward shock on the UPCLS in the long run. There is evidence of complete price transmission existing between RPCLS and UPCLS which indicate that 292% of proportional change in RPCLS was transmitted to UPCLS while of 24% of proportional change in RPCOYS was transmitted to UPCLS in the long run.

Table 3: Estimated Vector Error Correction Model

Error correction	D(UPCLS)	D(RPCLS)	D(RPCOGS)	D(RPCOYS)
ecm(-1)	-0.518219	-0.875604	-60.16763	0.011993
	(-2.72738)	(-3.02283)	(-2.59706)	(0.06349)
D(UPCLS(-1))	0.016981	0.041134	-0.525427	-0.177698
	(0.07228)	(0.19377)	(-0.96003)	(-0.76083)
D(UPCLS(-2))	0.127267	0.163734	-0.486326	0.234338
	(0.56894)	(0.81007)	(-0.93325)	(1.05377)
D(RPCLS(-1))	0.006837	-0.081617	0.076672(	0.054907
	(0.02727)	(-0.36027)	0.13127)	(0.22029)
D(RPCLS(-2))	0.042522	-0.059299	0.536099	-0.183682
	(0.17350)	(-0.26778)	(0.93900)	(-0.75391)
D(RPCOGS(-1))	0.089765	0.070003	-0.007973	-0.013556
	(1.97300)	(1.70285)	(-0.07522)	(-0.29971)

D(RPCOGS(-2))	0.107487	0.105212	0.012954	0.080461
	(2.34287)	(2.53801)	(0.12121)	(1.76412)
D(RPCOYS(-1))	-0.098037	-0.049276	0.119264	-0.084675
	(-0.89007)	(-0.49512)	(0.46480)	(-0.77329)
D(RPCOYS(-2))	0.041515	0.016507	0.296259	0.074734
	(0.36705)	(0.16152)	(1.12436)	(0.66463)
C	0.007249	0.008720	0.018709	0.009299
	(0.83082)	(1.10613)	(0.92046)	(1.07214)
Adj. R-squared	0.549932	0.627562	0.875343	-0.015466
F-statistic	2.362885	3.327517	0.899729	0.824007
Log-Likelihood	66.3477	-56.9942	-127.54986	-116.9646

Figures in parentheses are t-values associated with the respective parameters.
Source: Data analysis, 2014

Evidence from the F-statistics and the adjusted R^2 in Table 3, suggests that the variables in the VECM significantly explained short run changes in UPCLS, RPCLS and RPCOGS at $p<0.05$, accounting for 55%, 63% and 87% of the short run variation in the series respectively.

The error correction coefficients in the UPCLS, RPCLS and RPCOGS equations were significant ($p<0.01$) and associated with the desirable negative signs. This showed that UPCLS in Southwest, Nigeria, adjusts significantly to shocks to its equilibrium relationship with its hypothesized determinants that are caused by exogenous changes in past values of UPCLS, RPCLS and RPCOGS.

Effects on UPCLS of shocks that destabilize the equilibrium relationship between UPCLS and its determinants are corrected within 1.9 months (58 days). The speed of adjustment of 51%, 87% and 60% from the short run to the long run equilibrium is relatively high as compared to a perfect adjustment of 100% threshold. This indicated that there is a strong integration among the cowpea markets.

Focusing on the short term coefficient (elasticities) results in Table 3, when compared with co-integrating equation in 5 showed that while RPCLS, RPCOGS and RPCOYS significantly influenced Urban price of Cowpea in Lagos state in the long run, the short run impacts of RPCOGS and RPCOYS on UPCLS were significant, with only past values of UPCLS, RPCOGS and RPCLS being the main determinants of the current values of UPCLS.

Direction of Causality between Rural and Urban Market Prices

Table 4 shows the pairwise granger causality of cowpea. The result showed that out of the 24 cowpea market links investigated for evidence of granger causality, 15 markets links rejected their respective null hypotheses of no granger causality out of which 12 were bi-directional and 3 were uni-directional. The Rural Price of Cowpea in Lagos State (RPCLS) and Urban Price of Cowpea in Lagos State (UPCLS) granger causes and Rural Price of Cowpea in Ogun

State (RPCOGS) uni-directionally. For bi-directional granger causality, it was found that Rural Price of Cowpea in Oyo State (RPCOYS) granger causes UPCLS while RPCLS granger causes Urban Price of Cowpea in Lagos State (UPCLS). Also, RPCOGS granger causes their urban counterpart in Oyo State.

However, Rural Price of Cowpea in Oyo State (RPCOYS) has strong exogeneity over rural and urban markets of other States. Hence, it occupied the leadership position in price formation and transmission. Also, many of the market series are spatially linked by trade. Therefore, there is high market integration between the rural and urban markets. The implies that price changes in one market manifest an identical price response in other market. There is also adequate free flow of cowpea between the markets. Thus, the markets are highly linked by efficient arbitrage.

The result of the pairwise granger causality test also confirmed that RPCOYS occupied the leadership position in price formation and transmission. This is because price formed in RPCOYS is efficiently transmitted to the other (follower) markets (RPCLS and RPCOGS) with very minor distortions during the transmission process.

Table 4: Pairwise Granger Causality Result of Cowpea Markets

Null Hypotheses	**F-statistic**	**Prob.**
RPCLS does not granger cause UPCLS	0.4024	0.8064
UPCLS does not granger cause RPCLS	1.5237	0.2014
RPCOGS does not granger cause UPCLS	6.7688	7.7834
UPCLS does not granger cause RPCOGS	2.5845	0.0418**
RPCOYS does not granger cause UPCLS	5.0807	0.0009***
UPCLS does not granger cause RPCOYS	4.8561	0.0013***
RPCOGS does not granger cause RPCLS	6.7885	7.5280
RPCLS does not granger cause RPCOGS	2.4035	0.0550**
RPCOYS does not granger cause RPCLS	3.3566	0.0129**
RPCLS does not granger cause RPCOYS	6.2435	0.0001***
RPCOYS does not granger cause RPCOGS	2.8488	0.0280**
RPCOGS does not granger cause RPCOYS	5.9823	0.0002***
RPCLS does not granger cause UPCOGS	1.4579	0.2211
UPCOGS does not granger cause RPCLS	4.8561	0.0004***
RPCOGS does not granger cause UPCOGS	0.0807	0.9880
UPCOGS does not granger cause RPCOGS	0.0917	0.9848
RPCOYS does not granger cause UPCOGS	2.4048	0.0549**
UPCOGS does not granger cause RPCOYS	5.9355	0.0002***
RPCLS does not granger cause UPCOYS	3.1481	0.0177**
UPCOYS does not granger cause RPCLS	3.1411	0.0179**
RPCOGS does not granger cause UPCOYS	3.9075	0.0055***
UPCOYS does not granger cause RPCOGS	3.0212	0.0215**
RPCOYS does not granger cause UPCOYS	6.7524	7.9555
UPCOYS does not granger cause RPCOYS	0.5479	0.7009

*****,** ** and * implies statistic is significant at p<0.01, 0.05 and p<0.1

Source: Data analysis, 2014

Conclusions and recommendation

This study examined the spatial integration and price formation of cowpea markets in Southwest Nigeria. Results showed a strong relationship between the urban and rural retail market prices of cowpea. High price transmission elasticity values for cowpea prices again showed that, an increase in urban prices was capable of provoking a rise in rural prices in all the States. There was a strong relationship between the pairs of market prices of cowpeas. The speed of adjustment from the short run to the long run equilibrium for the price series is relatively high as compared to a perfect adjustment of 100% threshold. This indicates that there is a strong integration among the three markets

In conclusion therefore, RPCOYS occupied the leadership position in price formation and transmission. This is the central market influencing price transmission of cowpea in southwest Nigeria. Hence, prices in other markets were dependent on their past values and on current and past values of this central market price.

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