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Price Transmission and Integration of Cocoa and Palm Oil Markets in Cross River State, Nigeria: Implications for Rural Development

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Abstract: Full price transmission and spatial market integration are hallmarks of market efficiency that enable a market system to perform its development functions; the gains of which can be enjoyed by producers, middlemen and consumers in the marketing chain. The integration of cocoa and palm oil markets in Cross River State is necessary if producers who are mostly dwellers in the rural areas where cocoa and oil palm plantations are sited are to benefit from being part of the marketing system. This study was concerned with testing for long-run market integration as well as determining the degree and speed of price transmission in cocoa and palm oil markets in the State using standard econometric techniques. Results show that cocoa markets with respect to Factors between Ikom and Akamkpa as well as Etung are fully integrated in the long-run, with price transmission elasticities of approximately 1.00 (indicating that the law of one price holds in the markets) as well as very high speed of price transmission from the central to the rural markets. However, the markets for cocoa Licensed Buying Agents (LBA) were not integrated. By the same token, palm oil markets between Ikom and Akamkpa are perfectly integrated, with price transmission elasticity of 1.05, with very high speed of price transmission. Overall, the study concludes that producers of cocoa and palm oil in the State benefit from spatial arbitrage as suggested by the perfect integration of the markets and the fulfilment of the law of one price. The implications here are that since these cocoa and oil palm estates are located mostly in the rural areas, incomes of the rural people can be greatly enhanced with expanded opportunities and incentives for them to intensify their production and/or go into the production and sale of cocoa and palm oil.

Key words: Cocoa, cointegration, palm oil, spatial arbitrage, rural incomes

INTRODUCTION

Cocoa and oil palm have been major contributors to agricultural Gross Domestic Product (GDP) in Nigeria and have consequently received substantial attention in literature. The major cocoa producing areas in the country are located in the South-Western region, while the major oil palm producing areas are located in the South-South and South-Eastern regions of the country. Cross River State is a major producer of oil palm and produces about a sixth of the nation's total output from cocoa.

In fact, the Agricultural Development Corporation (ADC) of the then Cross River State which was the commanding height of the State's economy was made up of cocoa, oil palm and rubber plantations. However, due to inefficiencies in the management of the ADC because of its status as a government parastatal, the estates were privatised at some point and managed by government appointed teams at other times. Recently, the Cross River State government in an effort to alleviate poverty in the rural communities where these plantations are sited has adopted the small-holder scheme in its cocoa and oil palm estates. Under this arrangement, plots in the plantations are leased to individuals to manage and pay a token to the government at the beginning of each year.

Nonetheless, for the scheme to achieve its objectives of poverty reduction and rural development there has to be an efficient marketing/distribution system for the products of cocoa and oil palm, as changes in supply and demand conditions in one market would affect their trade and therefore prices in other markets, since they are basically produced for cash (the market). Consequently, the marketing efficiency of these products in different locations in the State becomes an issue of interest.

Essentially, an efficient marketing system is one where there is market integration and full price transmission, which is why the perfectly competitive market condition is thus said to be the ideal market structure for market integration, given that its attributes ensure that prices adjust instantaneously to any new

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information. According Okoh and Egbon (2002) the concern of market integration analysis is therefore, to determine the possibility of obtaining some gains by trading across commodity markets, exploiting movements in one market (urban) for the prediction of price movements in another market (rural).

Furthermore, an efficient marketing system will remove the problems of unprofitable arbitrage and isolation of spatially differentiated markets and ensure that efficient allocation of resources across space and time is achieved. Apart from these, knowledge of the state of integration in the domestic market system will help market intermediaries to identify substitution possibilities between markets and between commodities. According to Lee (2005) market integration is very vital in economic development in that it brings about increased production arising from specialization according to comparative advantage; increased output arising from better exploitation of scale economies; forced changes in efficiency arising from increased competition within the group; among others.

In Cross River State, cocoa and palm oil trade has Ikom as a popular central destination for movement of cocoa beans and palm oil to other parts of the country for either industrial or domestic use or export. In this regard, Etung and Akamkpa are taken as peripheral markets which prices are determined by those prevailing in Ikom. Thus, it is reasoned that if there are synchronous movements of prices between these locations and Ikom, then small producers in the rural communities stand to gain from such harmony as increase in central prices will be transmitted back to the rural market. In this study the rural producer will not suffer from price instability as they will always have knowledge of price behaviour before hand. Apart from the integration or convergence of prices in the market system, the degree and speed of price transmission is of the essence. This is because the principle of market efficiency has the Law of One Price (LOP) as its pivot. When price transmission is full, the law one price is said to hold. The main concern of the law of one price (which draws from the theory of perfect competition) is that prices of all transactions will tend to uniformity, allowing for differences in transportation costs between different spatial markets. This is true except inefficiencies exist in the system. The major consequence of which is that price changes will not necessarily coincide with the equilibrium path of demand and supply of the product.

This study therefore, is concerned with determining the degree as well as speed of transmission of cocoa and palm oil prices from Ikom to Etung and Akamkpa based on the central market hypothesis and the law of one price and with testing for market integration between cocoa and palm oil markets in Ikom and each of Etung and Akamkpa using cointegration and error correction model with a view of providing policy implications based on the results.

MATERIALS AND METHODS

The data: The price data used for this study were weekly time series, which were collected over a period of 52 weeks from a cross-section of 69 respondents for cocoa and the weekly spot prices for the three markets for palm oil, in the year 2005.

Particularly, for cocoa, 8 Licensed Buying Agent stores each were selected in each of the Local Government Areas, while 15 factors each were located from the stores in each Local Government Area, thus making a total of 24 Licensed Buying Agents and 45 factors in the study. With respect to palm oil, Ikom central market, Mbarakom market for Akamkpa and Bendeghe-Ekiem market for Etung were chosen for the collection of the weekly prices of palm oil.

Analytical methods: The method of analysis used in this is the cointegration and error correction model. Particularly, the Johansen's method of cointegration, which results in the Vector Error Correction Model (VECM), was used. The vector error correction model is an extension of the Vector Auto-Regression (VAR) model developed by Sims (1980), Johansen and Juselius (1990) and Johansen (1991).

Model specification: We begin by specifying a model relating prices of cocoa and palm oil in rural or peripheral markets to their respective prices in a central market based on the central market hypothesis of spatial markets (Ezedinma *et al*., 2006; Asche *et al*., 2005; Goodwin and Holt, 1999). The basic assumption in this model is that rural/peripheral market prices are driven by the prices, which prevail in the central market.

It is hypothesized that within the model, the Rural Market Price (RMP) and the Central Market Price (CMP) are jointly determined (that is endogenous to the system) while any other variable is exogenous to the system. Given this condition, the Vector Auto-Regression (VAR) representation of our model involving two endogenous variables, without any exogenous variable, following Sims' (1980) can be specified as:

$$Z_t = \delta + A_1 Z_{t-1} + A_2 Z_{t-2} + \dots + A_{P-1} Z_{t-P+1} + U_t \qquad (1)$$

Where:

Z_t is a $(n\times1)$ vector of non-stationary I(1) endogenous variables;

δ is a $(n\times1)$ vector of parameters;

A_i are $(n\times n)$ matrix of parameters;

U_t is an (n×1) vector of random variables, distributed as empirical white noise.
From the above specification,

$Z_t = [LnRMP_t, LnCMP_t]'$

Where:
$LnRMP_t$ is rural market price; and
$LnCMP_t$ is central market price.

Since we want to distinguish between stationarity by linear combinations and by differencing, the VAR in Eq. 1 can be re-written in its vector error correction form thus:

$$\Delta Z_t = \delta + \Gamma_1 \Delta Z_{t-1} + \Gamma_2 \Delta Z_{t-2} + \\ + \Gamma_{P-1} \Delta Z_{t-P+1} + \Pi Z_{t-P} + U_t \qquad (2)$$

Where:
Z_t is a vector of non-stationary I(1) endogenous variables;
$\Delta z_t = Z_{t-1}$; Π and Γ_i are (n x n) matrices of parameters with;
$\Gamma_I = -(I - A_1 - A_2 - ...A_i)$ (I = 1, ...k − 1) and $\Pi_1 - \Pi_2 .....\Pi$.

From the above specification, the information about the short-run and long-run adjustments to the changes in Z_t through the estimates of Γ_i and Π, respectively can be obtained. The Γ matrix in Eq. 2, which is termed the long-run impact matrix of the error correction mechanism, is of primary importance. First the rank of Π provides the basis for determining the existence of cointegration or long-run relationship between variables. According to Johansen (1988) there are three possibilities with regard to the rank of Π: if rank (Π) is zero, then the variables are not cointegrated and the model is equivalent to a VAR in first differences;
if 0<rank (Π)<n, then the variables are cointegrated and
if the rank(Π) = n, then the variables are stationary and the model is equivalent to a VAR in levels.

Second, since the term ΠZ_{t-k} provides information about the long-run equilibrium relationship (cointegrating relationship) between the variables in Z_t, the Π matrix can be decomposed into the product of matrices α and β, that is, $\Pi = \alpha\beta$. Where α is the matrix of speed of adjustment coefficients which characterises the long-run dynamics of the system, while β is the matrix representing the cointegrating relations in which βZ_t (the disequilibrium error) is stationary (Johansen and Juselius, 1990; Chang and Griffith, 1998). A large value of α means that the system will respond to a deviation from long-run equilibrium very quickly (that is, with a rapid adjustment) and vice versa.

Given the above vector error correction model in Eq. 2, the long-run cointegrating equation for the rural market price can be written as:

$$LnRMP_t = \phi_0 + \phi_1 LnCMP_1 + \varepsilon_t \qquad (3)$$

Where:
ϕ_0 is a constant term that captures transportation costs and quality differences;
ϕ_1 is the long-run static coefficient which gives the relationship between the prices (i.e., the price transmission elasticity); and
ε_t is the random term with the usual stochastic assumptions.

Generally, if $\phi_1 = 0$, there is no relationship between the prices; while if $\phi_1 = 1$, the Law of One Price (LOP) holds and the relative price is constant. In this case, the goods in question are perfect substitutes. If $0<\phi_1<1$ (indicating a positive partial relationship), there is a relationship between the prices, but the relative price is not constant and the goods will be imperfect substitutes. If $0>\phi_1<1$ (indicating a negative partial relationship), there is a relationship which indicates that the goods are complements.

Model implementation techniques: The study adopts the Johansen Maximum Likelihood procedure of cointegration. In this method, a preliminary analysis is carried out first to assess the order of integration of the data series through the use of unit root tests after which we test for the existence of cointegrating (long-run equilibrium) relationships among the data series. If a valid cointegrating relationship is found, then we estimate a vector error correction model, since cointegration is a pre-condition for the estimation of an error correction model.

Test for unit roots: To carry out the unit root test for stationarity, the study uses the Augmented Dickey-Fuller (ADF) test to examine each of the variables for the presence of a unit root (an indication of non-stationarity), since it can handle both first order as well as higher order auto-regressive processes, by including the first difference in lags in the test in such a way that the error term is distributed as white noise. The test formula for the ADF is shown in Eq. 4, respectively.

$$\Delta Y_t = \alpha + \rho Y_{t-1} + \sum_{t-1}^{j} \gamma \Delta Y_{t-j} + \mu_t \qquad (4)$$

Where: the lag length j chosen for ADF ensures that μ_t is empirical white noise. Here the significance of P is tested against the null that $p = 0_1$, based on t-statistics on P obtained from the OLS estimates of Eq. 6. Thus if the null hypothesis of non-stationarity cannot be rejected, the variables are differenced until they become stationary, that is until the existence of a unit root is rejected, before proceeding to test for co-integration.

Test for cointegration: The purpose of the cointegration test is to determine whether a group of non-stationary series are cointegrated or not. Engle and Granger (1987) pointed out that a linear combination of two or more non-stationary series may be stationary. Thus, if such a stationary linear combination exists, the non-stationary time series are said to be cointegrated. The stationary linear combination is called the cointegrating equation and may be interpreted as a long-run equilibrium relationship among variables.

To test for cointegration, we consider the vector error correction model specification in Eq. 2. Information about the number of cointegrating relationships among the variables in Z_t is given by the rank of the Π-matrix: if Π is of reduced rank, the model is subject to a unit root; and if $0<r<n$, where r is the rank of Π, Π can be decomposed into two (n x r) matrices α and β, such that, $\Pi = \alpha\beta'$ where, $\beta' Z_1$ is stationary. Here, α is the error correction term and measures the speed of adjustment in ΔZ_t and β contains r distinct cointegrating vectors, that is cointegrating relationships between non-stationary variables, as earlier stated.

The Johansen method uses the reduced rank regression procedure to estimate α and β and the trace test and maximal-eigen value test statistics were used to test the null hypothesis of at most r cointegrating vectors against the alternative that it is greater than r. The interest here is in testing for the presence of a valid cointegrating vector which gives a unique long-run equilibrium relationship. Once this is established, the vector error correction model of the form given below can be estimated.

$$\Delta RMP_t = \delta_{10} + \sum_{i=1}^{n}\delta_{11i}\Delta RMP_{t-i} + \sum_{i=1}^{n}\delta_{12i}\Delta CMP_{t-i} - \alpha(RMP_{t-1} - CMP_{t-1}) + U_t \quad (5)$$

$$\Delta CMP_t = \delta_{20} + \sum_{i=1}^{n}\delta_{21i}\Delta RMP_{t-i} + \sum_{i=1}^{n}\delta_{22i}\Delta CMP_{t-i} - \alpha(RMP_{t-1} - CMP_{t-1}) + U_t \quad (6)$$

Where all the variables are as earlier defined and Δ is the first difference operator, while δ_{11} to δ_{22} are short-run coefficients and α is the error correction mechanism which measures the speed of adjustment from short-run disequilibria to long-run steady-state equilibrium. U_t is the error term assumed to be distributed as white noise. All the estimations were performed using the standard version of eviews econometric software.

RESULTS AND DISCUSSION

Unit root tests: Table 1 shows the summary results of unit root (stationarity) test of the entire individual price series in the three Local Government Areas used for the estimations in the study. Clearly, it can be observed that on application of the ADF test on the log-level series, all of them were not stationary (that is contained a unit root) as indicated by the fact that their respective critical values are larger (in absolute terms) than the calculated ADF statistics, thus the null hypothesis of the presence of a unit root could be rejected. Consequently we applied the ADF test on the log of the differenced series, to make the stationary. The results indicate that all the series became stationary at first difference except the price for palm oil in Etung (LnEtung). The calculated ADF test statistics in this case are higher in absolute terms than the critical values, thus we reject the null hypothesis of the presence of unit root and proceed to test for cointergration.

Using the log-level form of the price series, we estimated bivariate cointergrating relations between each of the rural prices and the central market price to enable us see how the individual prices co-move in the long-run, given that a multivariate system may lead to the problem of dimensionality and loss of information about the speed of price transmission for each of the price series from one market to the other (Asche *et al.*, 2005; Johansen and Juselius, 1990)

Tests for cointegration: Table 2 shows the results of the bivarate cointegrating tests. We used the Johansen

Table 1: Results of Augmented Dickey Fuller (ADF) unit root test for cocoa and palm oil prices

Variable level	ADF statistic	Critical value	Variable first difference	ADF statistic	Critical value
Cocoa factors					
LnAkamkpa	-1.3057	-3.5683	ΔLnAkamkpa	-4.4195	-3.5683
LnEtung	-1.3023	-3.5683	ΔLnEtung	-4.3949	-3.5683
LnIkom	-0.9724	-3.5654	ΔLnIkom	-5.7690	-3.5683
Cocoa licensed buying agents					
LnAkamkpa	-1.3692	-3.5683	ΔLnAkamkpa	-4.4694	-3.5683
LnEtung	-1.4025	-3.5683	ΔLnEtung	-4.3784	-3.5683
LnIkom	-0.9687	-3.5654	ΔLnIkom	-5.2678	-3.5683
Palm oil					
LnAkamkpa	-1.6813	-3.5713	ΔLnAkamkpa	-4.2202	-3.5683
LnEtung	-1.8157	-3.5713	ΔLnEtung	-2.6010	-3.5713
LnIkom	-1.2677	-3.5683	ΔLnIkom	-4.4929	-3.5683

Critical values of ADF tests are based on MacKinnon (1996) one-sided p-values. Lag length selection is automatic based on Eviews' schwarz information criteria

Table 2: Results of bivariate (Pair-wise) cointegration tests between Ikom and Akamkpa and Etung

Null hypothesis	Trace statistic	5% critical value	1% Critical value	Max-eigen statistic	5%	1%
Cocoa factors Ikom and Akamkpa						
r = 0	20.7522	15.41	20.04	18.885	14.07	18.63
r≤1***	1.8710	3.76	6.65	1.8671	3.76	6.65
Ikom and Etung						
r = 0	21.9142	15.41	20.04	20.1251	14.07	18.63
r≤1***	1.7890	3.76	6.65	1.7890	3.76	6.65
Cocoa LBAs Ikom and Akamkpa						
r = 0	17.611	15.41	20.04	15.3218	14.07	18.63
r≤1	2.2892	3.76	6.65	2.2892	3.76	6.65
Ikom and Etung						
r = 0	17.1479	15.41	20.04	14.8611	14.07	18.63
r = 1	2.2867	3.76	6.65	2.2867	3.76	6.65
Palm oil Ikom and Akamkpa						
r = 0	30.2412	15.41	20.04	27.2827	14.07	18.63
r≤1***	2.95339	3.76	6.65	2.9539	3.76	6.65
Ikom and Etung						
r = 0	22.0498	15.41	20.04	17.4915	14.07	18.63
r≤1	4.5582	3.76	6.65	4.5588	3.76	6.65

(***) denotes cointegration at both 5 and 1% levels

Table 3: Summary results of the estimates of the long-run parameters (price transmission elasticities and speed of price transmission coefficients)

	Estimated ϕs	Estimated αs (ECMs)	Constant
Cocoa factors			
Ikom/Akamkpa	-0.9689 (-72.1651)***	-1.500 (-2.1410)**	-0.3256
Ikom/Etung	-0.9896 (-85.1013)***	-1.6752 (-2.1122)**	-0.1149
Cocoa LBAs			
Ikom/Akamkpa	-0.92316 (-39.4302)***	0.2917 (0.7303)	-0.7354
Ikom/Etung	-0.9478(-38.0230)***	0.3258 (0.8362)	-0.4897
Palm Oil			
Ikom/Akamkpa	-1.053 (-98.7207)***	-1.5131 (-4.1856)**	0.4698
Ikom/Etung	-0.9476 (-48.3120)***	0.1210 (0.4315)	-0.4550

(**), (***) denote significance at 5% and 1% levels, respectively

Maximum Likelihood method, which on its part relies on the trace test and maximal-eigen value test statistic to determine the rank r, of the long-run impact matrix n of the error correction mechanism. Results of the trace and maximal eigen value test indicate that for cocoa factors cointegration exist between Ikom and Akamkpa and among Ikom and Etung. For cocoa Licensed Buying Agents, there was no cointegration between the central and peripheral markets of Ikom and Akamkpa and Etung. Lastly, for palm oil, cointegration only existed between Ikom central market and Akamkpa, while the prices in Ikom and Etung did not co-move.

From the above results, it is clear that cocoa factor markets in Ikom and Akamkpa and Ikom and Etung and palm oil markets between Ikom and Akamkpa work in tandem with the spatial arbitrage condition which implies that market integration lends itself to cointegration interpretation with its presence being evaluated by means of cointegration tests (Rapsomanikis *et al.*, 2005). Thus, we can postulate that since these markets are cointegrated, there exist market integration between them such that there is a tendency for the prices in the 2 markets to converge in the long-run according to a linear relationship and that in the short-run the prices may drift apart, as shocks in one market may not be instantaneously transmitted to other markets or due to delays in transport. However, arbitration opportunities ensure that these divergences from the underlying long-run equilibrium relationship are transitory and not permanent.

Furthermore, the markets for cocoa Licensed Buying Agents (LBAs) show no evidence of spatial integration. This may be an indication that there may be leading prices in the opposite direction (thus, negating he central market hypothesis) or even between the markets involved and other markets not investigated in this study or some other constraint such as excessive interference of LBA operations in the State.

Vector error correction estimates: Table 3 shows the summary results of the long-run estimates of price transmission elasticities and speed of adjustment coefficients for each of the bivariate vector error correction equations. The results show that the estimated price transmission elasticities for cocoa Factors between Ikom and Akamkpa and between Ikom and Etung are-0.9689 and -0.9896, which are approximately 1.00 and are significant at the 1% significance level. This implies that there is a complete pass through of price changes from the central market in Ikom to Akamkpa and Etung indicating that the relative price between the prices in Ikom and those in the other two markets, respectively are constant, suggesting a constant return in prices. Clearly, the full transmission of price signals in the above scenario shows that the law of one price holds. This also is clearly the case with palm oil, between Ikom and Akamkpa which price transmission elasticity is -1.053, that is approximately 1.00.

Furthermore, the results of the estimated Error Correction Mechanisms (ECMs) corroborate the absence of cointegraton or a lack of market integration in cocoa LBA markets in the State as well as the palm oil market in Ikom and Etung, while also strengthening the results of cocoa Factors and palm oil markets in Ikom and Akamkpa. Specifically, the ECMs which indicate the speed of adjustment to disequilibrium errors for cocoa Factors between Ikom and Akamkpa and between Ikom and Etung are respectively -1.500 and 1.675 (both significant at 5% level). These imply that the ECMs indicate a feedback of about 150 and 167.5%, respectively of the previous week's disequilibrium from the long-run elasticity of Ikom prices. Particularly this shows that the speed at which Akamkpa cocoa prices adjust to changes in Ikom prices in an effort to achieve long-run static equilibrium is 150% while it is 167.5% for Etung, indicating that the speed of price transmission is very high and that full transmission is achieved in less than a few days within the week. Clearly, there is an overreaction of rural market prices as a result of changes in the central market price of cocoa in the State. This implies that cocoa prices in the rural markets change faster than normal as a result of changes in the central market price.

The estimated error correction coefficient for palm oil between Ikom and Akamkpa is -1.513 and it is significant at the 1% level of significance. This value indicates a feedback of about 151.3% of the previous week's disequilibrium from the long-run elasticity of Ikom palm oil prices. This is also an indication of an overreaction of Akamkpa palm oil prices as a result of changes in Ikom prices.

CONCLUSION

The current study has shown that cocoa markets at the factor level between Ikom and Akamkpa as well as between Ikom and Etung are fully integrated, while the LBA cocoa markets in the same locations are not. The results further show that the palm oil markets in Ikom and Akamkpa are also fully integrated while the markets in Ikom and Etung are not.

Furthermore, the study demonstrates that the speed of price transmission from the central market to the satellite or rural market with respect to the integrated markets is very high. All these point to the fact that these markets exhibit high level of efficiency which is a condition for profitable arbitrage and linking of markets. The high level of market efficiency points to the fact that cocoa producers/traders in Ikom and Etung benefit from market integration, at least at the factor level. Moreover, palm oil producers and traders in Akamkpa also benefit from the trade in palm oil between the two locations as the two markets are fully integrated.

The implications here are that since these cocoa and oil palm estates are located mostly in the rural areas, incomes of the rural people can be greatly enhanced with expanded opportunities and incentives for them to intensify their production and/or go into the production and sale of cocoa and palm oil. In fact, this will even create greater opportunities for economic growth and development as a result of the fact that market efficiency also increases technical as well as allocative efficiencies of producers.

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