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# Price Transmission and Market Integration: Vertical and Horizontal Price Linkages for Live Catfish in Nigeria

S.B. OHEN[1], S.O. ABANG AND I.C. IDIONG
*Department of Agricultural Economics / Extension, Faculty of Agriculture, University of Calabar, Calabar, Nigeria*
[1]Corresponding author's e-mail: suzyben01@yahoo.com

## ABSTRACT

The aim of this study was to explore price integration between producer prices, export and retail price of live catfish in Nigeria. Unit root test indicates that the prices were non-stationary and therefore were made stationary by first difference. The Johansen co-integration analysis was used to test for relationship between the prices. Results indicated that producer and export prices are co-integrated and form part of the same market. However, Granger causality Wald test suggested that retail price do have a causal relationship with producer prices. The dynamic regression analysis of prices also revealed that the markets for live catfish have strong price linkages and thus are spatially integrated.

**Key Words:** Market integration; Price transmission, Price linkages, Producer price, Export price

## INTRODUCTION

The size of the market for fish in Nigeria has been estimated at some 1.2 million tonnes in the early 2000s'. At wholesale value the market is worth over \$ 1 billion. The bulk market is for frozen imports; a low priced product retailing in the range of \$1 $kg^{-1}$ (i.e., N 150) to \$ 1.50 $kg^{-1}$ (N 220). Frozen fish common in Nigeria include Mackerel, Croaker, Sardines and Herrings. Fish are used by all classes of Nigerian and specially appreciated as a cheap source of protein. The Nigerian marine sector has been in decline for a number of years, most especially the industrial shipping sector, where the number of ships has fallen. Artisanal fishing makes up about 85 - 90% of the domestically caught fish. Fresh water catches amount to some 180,000 - 200,000 tonnes per annum, of which catfish types are the single most important category, probably amounting to about 40 - 50% of the catch. Supplies from this sector are on a decline.

Most rapidly expanding sector has been the supply of fish from fish farms and most notably catfish. These are marketed live and retailed at prices in the range of N 500 - 600 $kg^{-1}$ (Dixie & Ohen, 2006). The Nigerian catfish market is one of the biggest fresh fish markets. Large and intensive catfish farming is carried out in the South Western part of the country (over 70% of catfish farms are located in Oyo state & its environs). A large proportion of this production is traded in the South East, particularly Onitsha in Anambra state. There are very few fish farms in this area and a heavy reliance on interregional trade to satisfy its growing market for catfish.

Two common forms of analysis of the relationships between prices are market integration studies and analysis of marketing margins (Fackler & Goodwin, 2001; Wohlgenant, 2001). Studies on market integration attempt to investigate the extent of a market by analyzing the development of prices over time for potentially competing products. The interest for marketing margins or supply chains is how supply and demand shocks at one level of the supply chain are transmitted to the other levels within the chain. However, a feature that has not received much attention is that if different markets are integrated at the same or different level of supply chains, the supply chain for the product being examined can also be linked. Moreover if there is market integration at one level and a high degree of price transmission in the different supply chains, markets can also appear as integrated at different levels in the chain despite competition at all levels of the market.

Goodwin *et al*. (1990), explained that when investigating relationships between prices in market integration analysis, it is well known that there is in general a simultaneity problem as economic theory does not always give final answers to which variable is exogenous. This same problem is, in general present in the analysis of supply chains. This paper therefore reports a multivariate system to avoid this problem. A multivariate system is advantageous if one is interested in causality of price changes as different hypotheses then are nested within a multivariate system (due to simultaneity, the results from such test are questionable if one uses only single equation approaches). When price series are non-stationary, the Johansen test is the natural approach (Gonzales-Rivera & Helfand, 2001). We hypothesize that there is no co integrating vector ($r = 0$) in the marketing system of catfish. General objective of this study therefore was to explore price integration between producer prices, export and retail price of live catfish in Nigeria. The specific objectives include investigations on market integration and price transmission among markets involved and to examine if there is price causality in the system.

## MATERIALS AND METHODS

Catfish is consumed mostly as fresh in pepper soup. It is usually transported as whole fresh for consumption and further processing at Onitsha. Various intermediaries are involved in the trade between these two regions of Nigeria. There are several marketing problems in the catfish marketing system such as high transportation and storage. The fish is highly perishable and requires care in order to get to the final user in good shape. Therefore, the data set for this study contains weekly data of live catfish producer prices and export prices of farms in Oyo and the retail prices from Onitsha market for a period of 35 weeks. The data were taken on daily market days by trained enumerators at each location.

**Analytical framework.** Co-integration analysis involved establishing statistically sound long-run relationships between time series data. This implied that two interrelated prices of the same commodity should not diverge form one another to a great extent in the long-run (Granger, 1986). This analysis started with an investigation of the stationarity properties of each time-series. This study applied a standard augmented Dickey-Fuller (ADF) test of the following form to each price variable.

$$\Delta P_{it} = \beta_o + \beta T + \rho P_{i,t-1} + \sum_{j=1}^{k} \alpha_j \Delta P_{i,t-j} + e_t \ldots\ldots\ldots\ldots(1)$$

Where

$\Delta$ = the difference operator

$P_{it}$ = the price of the fish specie i, at time, t and T is a time trend (Dickey & Fuller, 1979). The trend term captures the possibility of deterministic growth in time series over time. The null hypothesis was that the series is non-stationary [i.e., I (1)], (the critical assumption in the Johansen approach was that each time series is integrated of order one; I (1) against the alternative hypothesis of stationarity [i.e., I (0)]. The number of lagged difference ($\Delta P_{i,t-j}$) terms is specified in order to eliminate any serial correlation in the $e_t$ values. The null hypothesis will be rejected. The analyses are undertaken using the natural log of the prices. Critical values were linearly interpolated from Fuller (1976) and the p-values are MacKinnon approximations published in MacKinnon (1994). Normal statistical inference was not valid for linear regressions on non-stationary data as there were non-linear long-run relationships. However, if the data series in question have common stochastic trends, the linear combinations of the two non-stationary data series could be stationary and therefore said to be co integration (Engle & Granger, 1987). The Engle and Granger (1987) test and the Johansen test are the two most common approaches to testing for co-integration of data that are not stationary. Common problems of using the Engle and Granger test are those of arbitrary selection of dependent variables (as with stationary data) and failure to identify the number of co integrating vectors for multivariate cases. Given a vector, $P_t$, containing variables of interest, the Johansen test was carried out using the following VAR representation.

$$P_t = \sum_{i=1}^{k} \Pi_i P_{t-i} + \Pi_k P_{t-k} + \mu + e_t \text{ ----------- } (2)$$

Where

Each $\prod_I$ was an n x n matrix of parameters and $\mu$ is a constant term. The system of equations was written in error correction form as:

$$\Delta P_t = \sum_{i=1}^{k-1} \Gamma_i P_{t-i} + \Gamma_k P_{t-k} + \mu + e_t \text{ --------}(3)$$

Where

$\Gamma_i = -1 + \prod_1 + \ldots + \prod_I$ and $i = 1,\ldots,k - 1$. Here $\Gamma_k$ is the long run solution to equation (4). If $\Delta P_t$ is a vector of I (1) stationary variables, then the left hand side and the first k-1 variables on the right hand side of the equation (4) are stationary I (0) and the error term, $e_t$ is by assumption, stationary. Hence, either $\Gamma k$ must be a matrix of zeros or $P_t$ contains a number of co integrating vectors. The rank of $\Gamma_{k,}$ defined by r, determines how many linear combinations of $P_t$ are stationary. If $r > 0$, then the variables are stationary in level, if r = 0, there exists no linear combinations that are stationary, and if $0 > r < N$, there are r stationary linear combinations of $P_t$.

The Johansen approach tests for the number of co-integrating ranks were not co- integration directly. In this framework, there were two asymptotically equivalent tests for co-integration, a trace test and the maximum eigen value test. The calculated statistics for the trace test and the maximum eigen value tests werew used to test the null hypothesis that there existed no co-integrating vector (r = 0) (the alternative hypotheses for the trace & maximum eigen value test being r > 0 and r = 1, respectively) and that there existed less than or equal to one co integrating vector ($r \leq 1$) (the alternative hypotheses for the trace and maximum eigen value tests were r > 1 and r = 2, respectively). The Johansen framework can be applied to stationary and non- stationary data.

Analysis of relationships between prices is a common tool in market integration analysis. This is based on market definitions as old as modern economics (Cournot, 1971). The logarithms of prices in question are most commonly used in econometric analysis to measure market integration. The basic relationship to be investigated is then:

$$\text{Ln } P_{1t} = \alpha + \beta \ln P_{2t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Where $\alpha$ is a constant term (the log of a proportionality coefficient) that captures transportation costs and quality differences and $\beta$ gives the relationship between the prices.

Aprori conditions specify that if $\beta = 0$, there are no relationships between the prices. B = 1, the law of one price holds and the relative price is constant. In this case the goods in question were perfect substitutes. This implied that the two markets were perfectly spatially integrated. Price changes in one market were fully reflected in alternative market. $0 \leq \beta \leq 1$, there is a relationship between the prices but the relative price is not constant and the goods will be imperfect substitutes. The degree of integration is evaluated by investigating how far the deviation of β is from unity.

## RESULTS AND DISCUSSION

The results of the ADF are presented in Table I (with a constant & with trend + constant) for producer prices, export prices and retail prices of catfish. For each price series, the null hypothesis of was not rejected. Hence each series were not stationary. The series were made stationary by first difference. Johansen test was used to investigate co-integration, with a dynamic regression analysis employed to identify the most significant co integrating vector.

Results of the Johansen co-integration tests for producer and export prices are given in Table II. The null hypothesis of no co-integrating vector (r = 0) was rejected at $P < 0.05$. This indicated that producer and export prices were co-integrated with one co-integrating vector. This provided evidence that the producer prices and export prices of live catfish form part of a system of live catfish prices that may vary independently in the short-run, but in the long-run, they will vary simultaneously as part of a single market. However Granger causality Wald tests was performed to test the causality of prices (Granger, 1969). This tested the null hypothesis that the causal variable did not cause the variable in question. The null hypothesis that export price caused no producer price (test 1) could not be rejected. The results showed that there was no causal relationship between the producer and export prices (Table III).

The results between the export and retail prices indicate that the null hypothesis of no co-integrating vector (r = 0) and (r ≤ 1) could not be rejected (Table IV). This indicated that these prices were not co-integrated though they formed part of a system of live catfish prices. Granger causality Wald tests was also performed to test the causality of these prices (Granger, 1969).

Test 1 suggested that the retail prices had a causal relationship with the export prices. Hence it was suggested that retail prices caused export prices and not vice versa. The null hypothesis that export prices caused no retail prices could not be rejected (Test 2). Hence, the log of the export prices did not have causal effect on the log of retail prices (Table V). Data also indicates that the null hypothesis of no co integrating vector (r = 0) and (r ≤ 1) cannot be rejected. Indicating that these prices are not co integrated. Test 1 suggested that the retail prices had a causal relationship with the producer prices. This tested the null hypothesis that the causal variable does not cause the variable in question. The null hypothesis that producer prices caused no retail prices could not be rejected (Test 2). Hence the log of the producer prices had no causal effect on the log of retail prices. This result also indicates that the null hypothesis of no co integrating vector (r = 0) and (r ≤ 1) cannot be rejected. Indicating that these prices are not co integrated.

**Table I. ADF test results for producer price, Export price and Retail price of live catfish**

| Variable | ADF levels (constant included) | ADF levels (constant + trend) | ADF 1st Difference (constant) | ADF 1st Difference (constant + trend) |
|---|---|---|---|---|
| Producer prices | -0.7469* | -2.2183* | -6.4977* | -6.4132* |
| Export prices | -0.8007* | -2.0362* | -6.4503* | -6.3741* |
| Retail prices | -0.2320* | -2.0546* | -6.2032* | -6.1706* |

* Significant at 5% and 1%

**Table II. Johansen tests for co integration for producer prices and export prices of catfish**

| Producer prices and export prices | Trace test | Max test |
|---|---|---|
| r = 0 | 16.8822* | 15.6325* |
| r ≤ 1 | 1.2497 | 1.2497 |

* Indicates significance at 5% level. Number of observation = 33 after adjusting end points. Number of lags = 1. To 1 Trace and max – eigen value test indicates 1 cointegrating vector at the 5% level

**Table III. Granger causality Wald test results for producer and export prices of live catfish**

| Test | Variable | Causal variable | $X^2$ - statistic | P-value |
|---|---|---|---|---|
| 1 | Producer prices | Export prices | 1.08617 | 0.3513 |
| 2 | Export prices | Producer prices | 0.3037 | 0.7404 |

**Table IV. Bivariate Johansen test for co integration for Export price and retail price of live catfish**

| Export prices and retail prices | Trace test | Max test |
|---|---|---|
| r = 0 | 10.7251 | 10.6905 |
| r ≤ 1 | 0.0345 | 0.0345 |

**Table V. Granger causality Wald test results for export prices and retail price of live catfish**

| Test | Variable | Causal variable | $X^2$ - statistic | P – value |
|---|---|---|---|---|
| 1 | Export prices | Retail prices | 7.7933 | 0.0020* |
| 2 | Retail prices | Export prices | 0.1796 | 0.8364 |

* Indicates significance at 1% level

Test 1 in suggests that the retail prices do have a causal relationship with the producer prices (Table VI). This tests the null hypothesis that the causal variable does not cause the variable in question. The null hypothesis that producer prices do not cause retail prices can not be rejected (Test 2). Hence the log of the producer prices does not have a causal effect on the log of retail prices (Table VII). On conducting a dynamic regression analysis on these prices, the study found out that there is a strong spatial linkage among the markets involved in the study. The slope parameter β indicated the relationship between two markets. If the markets are perfectly spatially integrated, the slope parameter β is one or near to one (Lahano & Mari, 2005). The estimated slope parameter for producer and retail prices is 1.1675 and for producer and export prices, it is 1.1991. This indicates that the price change in retail prices is fully

**Table VI. Johansen tests for co integration for producer prices and retail prices of live catfish**

| Producer prices and retail prices | Trace test | Max Test |
|---|---|---|
| r = 0 | 11.9501 | 11.9178 |
| r ≤ 1 | 0.0322 | 0.0322 |

Number of observations = 33 after adjusting end points. Number of lags = 1

**Table VII. Granger causality Wald test results for producer prices and retail prices of live catfish**

| Test | Variable | Causal variable | $X^{2-}$statistic | P – value |
|---|---|---|---|---|
| 1 | Producer prices | Retail prices | 8.4265 | 0.0013* |
| 2 | Retail prices | Producer prices | 0.3526 | 0.7059 |

* Indicates significance at 1% level

**Table VIII. Regression results of spatial price relationship in live catfish markets**

| Dependent variable | Independent variable | Intercept α | Slope β | $R^2$ |
|---|---|---|---|---|
| Producer prices | Retail prices | -1.6988 (-2.8621)** | 1.1675 (12.5473)* | 0.82 |
| Export price | Retail prices | -0.1982 (-0.3996) | 0.9641 (12.3974)* | 0.82 |
| Producer prices | Export prices | -1.3884 (-8.9770)* | 1.1991 (46.1447)* | 0.98 |

Figures in parenthesis are t-statistics.
*Significant at 1% level
**Significant at 10% level

reflected in producer prices. A change of N1.1675 in catfish retail price brings the same change in catfish producer prices. Also, a N1.1991 change in producer prices will bring the same change in export prices (Table VIII). The estimated slope parameter β for export and retail prices also indicates strong spatial price linkages among these markets. Therefore the study indicates that the live catfish markets are spatially integrated.

## CONCLUSION

Results indicated that producer and export prices were co-integrated, suggesting that market prices moved synchronously in the long-term as part of a single market. This implied that shocks or measures at any one point within the supply chain were to a large extent transmitted effectively within the chain. Further policy intervention in key areas such as infrastructures and credit for more efficient interregional trade in catfish.

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