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Cointegration and Market Integration: An Application to the Marine Fish Markets in Orissa

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Marine fish production in Orissa has increased significantly over the years rrom 38.70 thousand tonnes in 1980-81 to 133.46 thousand tonnes during 1996-97. However, about 55 per cent of the total catch (73.40 thousand tonnes) was exported outside the state during 1996-97. The intermediaries play a vital role in marine fish marketing in the state. The fishermen heavily depend upon the middlemen for marketing of their catch at various landing centres (72 in number) of the state. The existing marketing structure does not favour the poor fishermen of the state and thus both the fishermen and consumers have not benefited. In this study an attempt has been made to find out whether marine fish markets in the state are integrated to bring about efficiency in the marketing system.

DATA AND METHODOLOGY

The data pertaining to marine fish prices (bigger category of marine fish landed at Orissa coast) prevailing in different marine fish markets in the state are collected from the Department of Civil Supplies, Government of Orissa, Bhubaneswar for the period January 1984 to December 1992. The data pertain to the weekends for the last week of twelve months for the aforesaid years. The price is in Rs./kg. Six marine fish markets are chosen from among the 30 odd marine fish markets for which data are available in the Department of Civil Supplies. The centres thus selected are Berhampur, Bhubaneswar, Chandbali, Cuttack, Paradip and Rourkela.

The recent move towards market reform in most developing countries has renewed the interest in the working of agricultural markets as a source of income, employment and food security. The success of the reform process in promoting equity and efficiency is constrained by numerous structural deficiencies in local markets. One of the main consequences of these structural deficiencies is poor market integration, the difficulty with which information and trade flows among spatially separated markets. Therefore, among other things, the reform process needs to take into account the extent of agricultural market integration.

Market integration may be defined as a situation in which arbitrage causes prices in different markets to move together. Thus, more specifically, two markets may be said to be spatially integrated, whenever trade takes place between them, if the price differential for a homogenous commodity equals the transfer costs involved in moving that commodity between them. However, imperfections in the market, particularly those arising from activities of traders are generally taken as important causes for the existence of differential price movements in different markets (for a detailed discussion,

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see Baharumshah and Habibullah, 1994, p. 205).

Spatial price relationships have been widely used to indicate overall market performance. The usual definition in the literature is that integrated markets are those where prices are determined interdependently. This has generally been assumed to mean that the price changes in one market will be fully transmitted to the other markets. Markets that are not integrated may convey inaccurate price information that might distort marketing decisions and contribute to inefficient product movements. An attempt is made in this study to determine whether marine fish prices in a market are in parity with prices in a reference market. So it is necessary to compare market prices of marine fish in one market with fish prices among the other markets in the state. Bivariate price correlation as well as the methodogy developed by Engle and Granger (1987) has been used to show whether marine fish markets are cointegrated or not.

PRICE SERIES CORRELATION

Price in one market do vary with the actions of buyers and sellers in other markets. The degree to which price formation in one market is related to the process of price formation in other markets can be shown through a zero-order correlation matrix of prices in these markets. The approach presumes that with random price behaviour expected of a non-integrated market, the bivariate correlation coefficient of price movements will tend to be zero. Conversely, in a perfectly integrated market, correlation coefficient of price movements is expected to be unity.

The simple correlation coefficient for the prices in each pair of selected markets can be estimated by the following formula (Acharya and Agarwal, 1994, pp. 216-217):

$$r = \frac{\sum (P_{1i} - \bar{P}_1)(P_{2i} - \bar{P}_2)}{\sqrt{\sum (P_{1i} - \bar{P}_1)^2 (P_{2i} - \bar{P}_2)^2}}$$

where

r = Simple correlation coefficient,

P_{1i} = Price of the commodity in the first market at i-th point of time,

P_{2i} = Price of the commodity in the second market at i-th point of time,

P_1 = Mean of prices in the first market,

P_2 = Mean of prices in the second market.

The estimates of correlation coefficients are tested for their significance against zero by using 't' test and against one by Fisher's 'Z' transformation and Standard Normal Distribution test.

UNIT ROOT AND COINTEGRATION TEST

To examine the price relation between two markets, the following regression model has been used:

$$P_{it} = a_0 + a_1 P_{jt} + E_t \qquad \ldots (1)$$

where P_i and P_j are price series of a specific commodity in two markets i and j and E is the residual term assumed to be distributed identically and independently. Parameter a_0 represents domestic transportation costs, processing costs, sales tax, etc. The test of market integration is straightforward

if P_i and P_j are stationary variables. Often, however, economic variables are non-stationary in which case the conventional tests are biased towards rejecting the null hypothesis. Thus before proceeding with further analysis, the stationarity of the variables needs to be checked (Granger and Newbold, 1977).

To test the univariate price series for stationarity, the Augmented Dickey-Fuller (ADF) test has been applied, which tests the null hypothesis of non-stationarity against an alternative of stationarity. The standard equation of the ADF test is:

$$\Delta P_t = q + (a-1)P_{t-1} + \sum_{i=1}^{n} c_i \Delta P_{t-i} + u_t \quad \text{....(2)}$$

The test statistic is simply the t-statistic, however, under the null hypothesis it is not distributed as student-t, but the ratio can be compared with critical values tabulated in Fuller (1976). In estimating equation (2), the null hypothesis is H_0: P_t is 1(1), which is rejected (in favour of 1(0)) if a-1 is found to be negative and statistically significant.

The definition of cointegration used here is that of Engle and Granger (1987). Before proceeding to test for market integration using the cointegration analysis, the nature of integration of the variables needs to be determined (for a discussion on this aspect, see Granger, 1986, pp. 262-264). The test involved regressing the first-difference of the residual series on residual lagged level and lagged dependent variables is as follows:

$$E_t = y_1 E_{t-1} + \sum_{k=1}^{N} o_k E_{t-k} + v_t \quad \text{....(3)}$$

Again the test statistic is the t-statistic of y_1. The critical values are tabulated in Davidson-Mackinnon (1993, Table 20.2, p. 722). If the estimated t-value for any of the price series market pair exceeds the critical values as indicated in the table, then the price series are cointegrated.

RESULTS AND DISCUSSION

Table 1 presents the bivariate correlation coefficients among the price series of the selected market pairs in the state. When calculated using the nominal price series for marine fish in six selected fish markets in Orissa, the bivariate correlation coefficients ranged between 0.60 to 0.85. The highest 'r' value has been observed for the market pairs containing Berhampur and Chandbali and lowest for the market pairs containing Cuttack and Chandbali.

Unfortunately, as has been pointed out by a number of commentators, bivariate correlation coefficients have problems. First, the values of 'r' will be biased upwards by the existence of common trends or seasonality in price data (Blyn, 1973; Harriss, 1979). In these circumstances, correlation coefficients can be high even if there is little arbitrage between markets. The modern econometric literature has taken this argument a stage further in noting the spurious regression results that arise when price series are non-stationary (Granger and Newbold, 1974). Second, the values of 'r' will be reduced if transfer costs are high or there are seasonal reversal in trade flows (Blyn, 1973; Timmer, 1974). In these instances, markets may be well integrated spatially according to the arbitrage conditions even though correlations of their prices produce low value of 'r'.

TABLE 1. ESTIMATES OF CORRELATION COEFFICIENTS FOR MONTHLY WHOLESALE PRICES OF MARINE FISH SPECIES BETWEEN PAIRS OF SELECTED FISH MARKETS IN ORISSA

Markets (1)	Berhampur (2)	Bhubaneswar (3)	Cuttack (4)	Chandbali (5)	Paradip (6)	Rourkela (7)
Berhampur	1.00	0.76	0.69	0.85	0.83	0.69
Bhubaneswar		1.00	0.78	0.71	0.72	0.80
Cuttack			1.00	0.60	0.73	0.71
Chandabali				1.00	0.81	0.75
Paradip					1.00	0.77
Rourkela						1.00

Stationarity and Cointegration

Testing for stationarity and cointegration is a relatively recent development in the time-series literature 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. If so, they are said to be integrated of the order 0, denoted 1(0), and standard regressions results apply. Tests for cointegration are applied to pairs (or groups) of series, that are all individually non-stationary, in order to determine whether a long-run relationship exists between them.

The results of the ADF tests applied to marine fish price series in the selected markets of Orissa are presented in Table 2. Two stages of the ADF test have been carried out. Initially, test has been performed on the price series in levels, which implied testing a null hypothesis that the series are integrated of the order 1 or higher (i.e., non-stationary and requiring at least one difference to become stationary) against an alternative that the series are 1(0). The results of this stage are shown in the first column of the Table 2 (level). The null hypothesis could not be rejected even at 10 per cent level for any of the price series.

Following this, tests are also performed on the first difference of the price series, which implied testing a null hypothesis that the price series (original) are integrated of the order 2 or higher (i.e., non-stationary and requiring at least two differences to become stationary), against an alternative that the series are 1(1). The results of this stage are shown in the second column of Table 2. The null-hypothesis could be rejected at 1 per cent level for Bhubaneswar, Chandbali and Rourkela marine fish price series and at 5 per cent level for Berhampur, Cuttack and Paradip. Therefore, the conclusion from the ADF procedure is that the price series for marine fish in selected fish markets in the state are all 1(1).

TABLE 2. UNIT ROOT TESTS FOR MARINE FISH PRICE SERIES IN SELECTED FISH MARKETS IN ORISSA

Markets (1)	Level [1(1)] Augmented Dickey-Fuller (ADF) Test (2)	First difference [1(2)] Augmented Dickey-Fuller (ADF) Test (3)
Berhampur	-0.97	3.26 **
Bhubaneswar	-1.01	-4.77***
Chandbali	-0.43	-4.13***
Cuttack	-1.46	-3.39**
Paradip	-1.56	-3.21**
Rourkela	-1.66	-4.05***

Note: *** Significant at 1 per cent level. ** Significant at 5 per cent level.
ADF critical values are -2.57 for 10 per cent level, -2.86 for 5 per cent level and -3.43 for 1 per cent level.

The strong evidence in favour of concluding that all price series are 1(1) means that it is now appropriate to proceed toward testing for cointegration among the different price series for the selected marine fish markets in the state. The test for cointegration is the Engle-Granger test, which uses a standard ADF test on the residuals on an Ordinary Least Squares (OLS) regression.

$$P_{it} = a_0 + a_1 P_{jt} + E_t \quad \ldots (4)$$

where P_{it} = price in market 'i', P_{jt} = price in market 'j'. This is known as the cointegrating regression. All possible pairwise combinations of price series of marine fish markets have been chosen and each market has been considered as both the dependent and independent variable in that equation. The test statistic presented in Table 3 obtained for all the pairwise markets are found to be less than the asymptotic critical value as reported by Davidson and Mackinnon (1993) even at 10 per cent excepting that of Cuttack-Paradip market pair. Thus the null hypothesis of no cointegration could not be rejected for almost all the selected marine fish markets in the state. Therefore, all the market pairs Cuttack-Berhampur, Cuttack-Bhubaneswar, Cuttack-Chandbali, Cuttack-Rourkela, Paradip-Berhampur, Paradip-Bhubaneswar, Paradip-Chandbali, Paradip-Rourkela, Berhampur-Bhubaneswar, Berhampur-Chandbali, Berhampur-Rourkela, Bhubaneswar-Chandbali, Bhubaneswar-Rourkela and Chandbali-Rourkela are assumed to be not integrated.

To summarise, tests carried out on the univariate price series for marine fish indicate that they are not integrated, though there is some evidence of integration among the Cuttack and Paradip markets due to close proximity of these two markets and good communication facilities. Therefore, it seems to be complete failure of market mechanisms in influencing the price change in one market to another market. Fish being highly perishable, necessitates sound packaging and immediate transportation to the consuming centres. Road infrastructure at the village site landing centres in the

Orissa coast is poor. Most of the landing centres do not have sound infrastructure for packing and transportation facilities for immediate transfer of landed fish species to the urban consuming centres. Also there is no steady supply of marine fish at the landing centres as marine fish landing in the coast is purely a chance factor. Orissa coast is frequently witnessing cyclones and storms of high degree and weather plays a crucial role in fish landings. Most of the boats/trawlers do not venture out for deep sea fishing and mostly catch fish within a limited distance. Thus whenever there is natural calamity, there is every possibility of short supply at the landing centres. Again when there is huge catch, due to poor infrastructure coupled with inadequate communication facilities, there is always a glut in the local markets adjacent to landing centres, though there exists demand in the urban consuming centres. Thus poor infrastructure and information technology act as the main barriers for better market integration in the existing marine fish markets.

TABLE 3. SUMMARY MATRICES OF COINTEGRATION (ENGLE-GRANGER) TESTS FOR MARINE FISH PRICE CHANGES AMONG SELECTED MARKET PAIRS DURING JANUARY 1984 TO DECEMBER 1992

Markets (1)	Berhampur (2)	Bhubaneswar (3)	Cuttack (4)	Chandbali (5)	Paradip (6)	Rourkela (7)
Berhampur		-1.74	-2.50	-2.26	-1.64	-2.12
Bhubaneswar		-	-3.08	-2.80	-0.60	-3.00
Cuttack			-	-2.58	-3.15*	-3.08
Chandbali				-	-1.70	-1.50
Paradip					-	-1.31
Rourkela						-

Note: Davidson-Mackinnon Asymptotic Critical Values (1993) are -3.13 at 10 per cent, -3.41 at 5 per cent and -3.96 at 1 per cent level.

* Significant at 10 per cent level.

CONCLUSION AND POLICY OPTIONS

Bivariate price series correlation and Engle-Granger test have been used to analyse the market integration for Orissa marine fish markets. The bivariate correlation coefficients for six selected market pairs ranged between 0.60 to 0.85. The highest 'r' value has been observed for the Berhampur-Chandbali markets (0.85) though both of them are the landing centres located at South and North Orissa coast respectively. The lowest 'r' value is observed for the market pair of Cuttack and Chandbali. However, of late, the price series correlation coefficient test has been discredited for testing the food market integration. This may be due to existence of common trends or seasonality in price data or due to non-stationary nature of the price series.

So Engle-Granger test has been employed to test the integration among the marine fish markets in the state. The Augmented Dickey-Fuller (ADF) test has been applied first to test the stationarity of the price series. All the six marine fish markets' (Cuttack, Chandbali, Berhampur, Bhubaneswar,

Paradip and Rourkela) price series are found to be non-stationary when ADF test was carried out on the levels thus necessitating further test on the first difference of the price series. The tests revealed that the price series for marine fish in the selected markets in the state are stationary after first difference.

Then cointegration test has been applied which is a standard ADF test on the residuals on an OLS regression. The test statistic obtained for all the pairwise markets are found to be less than the asymptotic critical value even at 10 per cent level excepting that of Cuttack-Paradip pair. Thus marine fish markets in the state are assumed to be not integrated. This is mainly attributed to poor infrastructural facilities at landing centres as well as at the terminal secondary markets. The poor market integration observed in this case reveals that marine fish markets in the state are quite uncompetitive. This necessitates strong and extensive government intervention designed to improve competitiveness to enhance market efficiency.

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