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Analysis of Spatial Cointegration amongst Major Wholesale Egg Markets in India

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Abstract

The performance of egg market has been studied through measurement of oneness in the egg markets. For this purpose, the Engle-Granger Cointegration test procedure has been applied to egg price series for major wholesale egg markets in the country, viz. Nammakal (Tamil Nadu), Calcutta, Chennai, Bangalore, Delhi and Hyderabad for the period 1982 to 2000. The study has indicated that the six major wholesale egg markets in the country are cointegrated apparently due to performance of market intelligence functions by the National Egg Coordination Committee (NECC) which helps in transmitting price signals across the length and breadth of the country through print media on day-to-day basis. The high degree of cointegration amongst various markets indicates that these markets are competitive and efficient at the wholesale levels. However, it still remains to be examined whether the poultry farmers and traders at the grass-root level are able to realize the prices declared by the NECC.

Introduction

Today, India is the world's 4th largest egg producer and the 5th largest broiler producer. The estimated egg and meat production in India has steadily gone up to 46.2 billion eggs, equivalent to approximately 2.54 million tonne eggs and 2.3 million tonne poultry meat in 2005-06 (GoI, 2006). Rising primary input costs such as medicines, feed, electricity, taxes, etc. in poultry coupled with domination of middlemen had led to the crisis of 1981-82 when egg prices fell drastically and over 20,000 marginal poultry farmers lost their only source of livelihood in India. In 1982, National Egg Coordination Committee (NECC) was formed as an institutional support to the then ailing Indian poultry sector. Since then, the NECC has been performing its designated functions, including declaration of market prices across various markets on daily basis, in order to enhance transparency in the egg marketing system.

Spatial market integration refers to a situation in which prices of a commodity in spatially separated markets move together due to arbitrage and the price signals and information are transmitted smoothly across the markets. With free flow of information in a competitive market, difference in prices of a product in the two markets would be equal to or less than transportation cost between them. Hence, spatial market performance may be evaluated in terms of the relationship between the prices in spatially separated markets. Estimation of bivariate correlation coefficients between price changes in different markets has been employed as the most common methodology (Cummings, 1967; Lele, 1967; 1971) for testing market integration.

Recent advances in the time series analysis, especially those related to studies in market cointegration have led to an explosion in the literature in many countries, including India (Faminow and

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Benson, 1990; Goodwin and Schroeder, 1991; Palaskas and Harriss-White, 1993; Alexander and Wyeth, 1994; Baharumshah and Habibullah, 1994; Goletti *et al*., 1995; Baulch, 1997; Behura and Pradhan, 1998; Ghosh, 2000; Basu and Dinda, 2003 and Deb, 2004). Most of the studies have been on market integration of food grains, fish and horticultural crops. But, the issue concerning market cointegration in respect of livestock and poultry products has not been dealt with adequately. Hence, the present study was conducted to examine the performance of major egg markets in the country in terms of spatial market co-integration.

Data and Methodology

Data pertaining to the daily wholesale prices of eggs in different markets were collected from various secondary sources such as poultry magazines, viz. *Poultry Punch*, *Poultry Flame*, *Poultry Today*, etc. and also from the records of NECC. The daily price data series were converted into monthly average price series, as has been demonstrated that increasing the frequency (from monthly to weekly or daily) of sampled observations does not significantly change the power of tests of cointegration (Hakkio and Rush, 1991). The major egg markets for which price series were compiled were: Bangalore, Nammakal, Calcutta, Chennai, Delhi and Hyderabad and the period was 1982 to 2000.

The finding that many time-series may contain a unit root has spurred the development of the theory of non-stationary time series analysis. Thus, the traditional approach to look for market integration through estimation of correlation coefficients amongst detrended price series is not adequate, as it could yield spurious results. Engle and Granger (1987) pointed out that a linear combination of two or more non-stationary series may be stationary. If such a stationary linear combination exists, the non-stationary time series are said to be cointegrated. The stationary linear combination is the set of cointegrating equations and may be interpreted as a long–term equilibrium relationship among the variables.

It was hypothesized that ‘the wholesale prices of eggs in different markets across the country are cointegrated’. Hence, the null hypothesis that the egg markets are not integrated has been tested by employing cointegration methodology developed by Engle and Granger (1987), in a bivariate analytical framework.

First, the price data series for all the markets were tested for the presence of unit roots employing Augmented Dickey-Fuller (ADF) test (Gujarati, 2004). The actual procedure of implementing the ADF test required estimation of the following three forms of equations for any of the three possibilities, i.e. a random walk process without drift, with drift or with both deterministic and stochastic trends. Therefore, the following regression equations were estimated under the null hypotheses H_0: $\delta = 0$ (existence of unit root or non-stationary time series) against the H_1: $\delta < 0$. The critical values for testing the hypothesis were obtained from MacKinnon (1996) one-sided p-values. For the prices of eggs in market Y during period t, i.e. Y_t, the first difference series in Y, i.e. $(Y_t - Y_{t-1})$ may be denoted by ΔY_t.

The Y_t without drift may be obtained by Equation (1):

$$\Delta Y_t = \delta . Y_{t-1} + a_i . \sum_{i=1}^{m} \Delta Y_{t-i} + e_t \qquad \ldots(1)$$

The Y_t with drift may be calculated by Equation (2):

$$\Delta Y_t = \beta_1 + \delta . Y_{t-1} + a_i . \sum_{i=1}^{m} \Delta Y_{t-i} + \varepsilon_t \qquad \ldots(2)$$

And, Y_t with drift around a stochastic trend may be obtained from Equation (3):

$$\Delta Y_t = \beta_1 + \beta_2 . t + \delta . Y_{t-1} + a_i . \sum_{i=1}^{m} \Delta Y_{t-i} + e_t \qquad \ldots(3)$$

where,

Y_t = Prices of eggs in market Y during period t,

ΔY_t = First difference series in Y, i.e. $Y_t - Y_{t-1}$,

t = Trend variable (1, 2, 3, … , n), n being the length of data series in years,

m = Number of lag differences (based on Modified Akaike Information Criterion),

ε_t = Error-term, and

β_1, β_2, δ and a_i = Estimated parameters.

Once it was established that the level price (original) series pertaining to all the wholesale egg markets were *integrated of same order*, and *were non-stationary*, the test of cointegration was applied. The two vectors are said to be co-integrating if they are integrated of same order and their linear combination is stationary or does not have unit roots. Equation (4) was estimated for the egg price series pertaining to two different markets, which were integrated of the same order [tested by ADF test] as outlined in Equations (1), (2) & (3):

$$Y_t = \beta_1 + \beta_2 .t + \beta_3 X_t + U_t \qquad \ldots(4)$$

Hence, $U_t = Y_t - \beta_1 - \beta_2 .t - \beta_3 X_t$

where,

X_t = Prices of eggs in X market during period t,

U_t = Error-term (White noise), and

β_1, β_2 and β_3 = Estimated parameters.

The ADF unit root test was again applied on the residual series (U_t). The two markets were said to be cointegrated if the U_t series was stationary, i.e. did not have a unit root.

Results and Discussion

Table 1 shows the results of ADF Unit Root test as applied to the individual wholesale egg price series pertaining to various markets to ascertain the univariate time series properties of the data and to confirm that all the price series were non-stationary and integrated of the same order. In Equation (1), if d coefficient was positive, it implied that the price series was explosive, which is far from reality. We were left with Equations (2) and (3). In both the

Table1. Results of ADF test for wholesale egg price series in various egg markets

Market	Equation (2)			Equation (3)		
	τ	*d*	F	τ	*d*	F
			(a) ADF Statistics - Level series			
Critical value, 1%	-3.463	-	8.43	-4.004	-	6.22
Critical value, 5%	-2.876	-	6.34	-3.432	-	4.75
Bangalore	0.199 (13)	2.025 *	9.26 *	-2.256 (11)	1.955 *	9.29 *
Calcutta	0.270 (14)	1.965 *	7.17 **	-2.421 (11)	1.976 *	8.58 *
Chennai	0.298 (12)	2.034 *	9.16 *	-2.183 (11)	1.939 *	8.93 *
Delhi	0.303 (14)	2.031 *	8.09 **	-1.991 (11)	1.999 *	9.09 *
Hyderabad	0.508 (12)	2.004 *	10.26 *	-1.897 (11)	1.960 *	10.39 *
Nammakal (Tamil Nadu)	0.213 (15)	1.966 *	12.22 *	-2.220 (15)	1.963 *	12.07 *
			(b) ADF Statistics - Ist difference series			
Critical value, 1%	-3.461	-	8.43	-4.002	-	6.22
Critical value, 5%	-2.875	-	6.34	-3.431	-	4.75
Bangalore	-16.719* (0)	2.076 *	279.54 *	-16.688* (0)	2.076 *	139.26 *
Calcutta	-17.735* (0)	2.040 *	314.52 *	-17.698* (0)	2.041 *	156.62 *
Chennai	-16.853* (0)	2.057 *	284.05 *	-16.821* (0)	2.058 *	141.47 *
Delhi	-14.452* (0)	1.998 *	208.85 *	-14.430* (0)	1.998 *	104.06 *
Hyderabad	-15.675* (0)	2.013 *	245.72 *	-15.650* (0)	2.013 *	122.40 *
Nammakal (Tamil Nadu)	-18.557* (0)	2.068 *	344.37 *	-18.528* (0)	2.069 *	171.64 *

Notes: τ=ADF test statistics; *d* = Durbin-Watson statistics and F denotes F test statistics.
* & ** denote significance at 1 per cent and 5 per cent levels, respectively.
Figures within the parentheses indicate number of lags in AR Model based on modified Akaike Information Criterion.
* *d* statistics significant at 1 per cent p-level (no serial correlation) at N (No. of observations) = 200 and k= No. of explanatory variables in the AR model = (No. of lags + 1).

Table 2. ADF test statistics for residuals (level series)

Y ↓ \ X →	Delhi	Hyderabad	Chennai	Calcutta	Nammakal (Tamil Nadu)	Bangalore
Delhi	-	-3.450* (14)	-2.901* (12)	-2.194** (11)	-3.442* (14)	-3.479* (14)
Hyderabad	-2.908* (14)	-	-2.673* (11)	-2.042** (11)	-3.471* (10)	-3.425* (14)
Chennai	-2.352** (14)	-1.998** (11)	-	-1.894*** (11)	-7.367* (5)	-7.827* (1)
Calcutta	-1.802** (11)	-1.991** (11)	-2.019** (11)	-	-2.612* (13)	-3.224* (14)
Nammakal	-2.599* (14)	-2.154** (11)	-7.248* (5)	-2.486** (13)	-	-10.379* (0)
Bangalore	-2.757* (14)	-3.098* (14)	-7.992* (1)	-3.204* (14)	-10.502* (0)	-

Notes: Dependent variables in rows and the corresponding explanatory variables in column in bivariate analytical frame.

*, ** and *** denote significance at 1 per cent, 5 per cent, and 10 per cent p-levels, respectively. Critical values of ADF statistics (τ) at 1 per cent = -2.576; at 5 per cent = -1.942 and at 10 per cent = -1.616 at N=200.

Figures within the parentheses indicate number of lags in AR Model based on Akaike Information Criterion.

equations, the estimated d coefficients were negative. In general, Equation (3) yielded better results than Equation (2). However, the final choice of model rested on the probability level of the estimated coefficient d at which it was significant so as to reject H_0.

A perusal of Table 1 reveals that although all the level (original) price series were non-stationary, as indicated by the non-significant values of the ADF statistics (t) , the first difference series pertaining to all the markets were almost stationary, since ADF statistics were significant at 1 per cent probability level. Thus, the test of cointegration could be applied as all the egg price data series were integrated of the same order, i.e. I(1) and did not have unit root.

The regression equations were fitted by taking level price series in one market as dependent variable and level price series in another market as explanatory variable (Equation 4) and the corresponding residual series were worked out. The residual (level) series were subjected to regressions corresponding to Equation (1), i.e. without intercept and trend variables in order to apply ADF test. Table 2 shows the results of the ADF test statistics applied to various residual series in a bivariate scheme. The significant values of the ADF statistics indicated that the residuals' series did not have unit root or it was stationary, implying that the corresponding markets were cointegrated. Thus, it can be seen from Table 2 that all the wholesale egg markets were cointegrated with one-another, implying that the prices of eggs were determined simultaneously in all the markets. This may be due to the market intelligence functions carried out by the NECC throughout the country.

Conclusions

The Engle-Granger test has been used to study cointegration amongst various wholesale egg markets in the country. The wholesale price data series have been subjected to ADF test for finding the presence of unit root. Having established the condition of non-stationary and integrating relationships of the same order, i.e. I(1), for individual price data series pertaining to different markets, the test of cointegration has been applied. In the process, the prices in one market (non-stationary) have been regressed upon prices (non-stationary) in the other market in a bivariate scheme and the residuals series, thus obtained has been again subjected to ADF test for examining the presence of unit roots. The two markets are said to be cointegrated if the residual series do not have a unit root.

The study has indicated that the six major wholesale egg markets in the country are cointegrated apparently due to performance of market intelligence functions by the NECC which helps in transmitting price signals across the length and breadth of the country through print media on day-to-day basis. The high degree of cointegration amongst various markets indicates that these markets are competitive and efficient at the wholesale levels. However, it still remains to be examined whether the poultry farmers and traders at the grass-root level are able to realize the prices declared by the NECC, through primary surveys.

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