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**Title of the poster paper**: Cointegration and Market Integration: An application to the Potato Markets in Rural West Bengal, India

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# **Cointegration and Market Integration:** *An Application to the Potato Markets in Rural West Bengal, India*

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*The paper attempts to examine the market integration with the help of cointegration test on the prices of potato of Hooghly district in West Bengal. The analysis has been made at two levels, namely at the level of wholesale markets and at the retail markets. The cointegration test by Johansen and Jeselius (1990) applied to weekly prices of three important potato markets in Hooghly district suggest that the markets are integrated. Our results revealed that price signals and information are transmitted smoothly across the markets. These results have important policy implications. In a situation when potato markets are spatially integrated the government may think of reducing or even withdrawing its efforts to influence the price in the market. The finding of the market integration appears to be quite significant for the success of price policy and market liberalisation programs undertaken in India.*

**Key words**: *Market Integration, Cointegration, Wholesale potato market, Retail potato market, Price signal and information.*

**JEL Classification**: Q13

The concept of market integration has retained and increased importance over recent year, particularly in developing countries where it has potential application to policy questions regarding government intervention in markets (Alexander and Wyeth, 1994). Unless agricultural product markets are spatially integrated, producers and consumers will not realize the gains from trade liberalization. If markets are not integrated, the correct price signals will not be transmitted through the marketing channels, the farmers will not be able to specialise according to long-term comparative advantage and the gains from trade will not be realised.

An integrated market is synonymous with pricing efficiency, i.e., prices as defined by Fama (1970), "should always reflect all information" (pp. 383-417).

The present study focuses on pricing efficiency in wholesale and retail markets. In recent years several studies relating to market integration have been done with the help of different statistical tools. 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 other markets (Behura and Pradhan, 1998). In making inferences about market efficiency from data on prices the concept of integration has been central ( Palaskas and Harriss-White,1993). Spatial market integration refers to a situation in which prices of a commodity in spatially separated markets move together and price signals and information are transmitted smoothly across the markets (Ghosh, 2000). In the sixties and the seventies, the methodological work on the measurement of pricing efficiency in agricultural commodity markets focused on pair-wise comparisons of price series data, i.e., the zero order correlation coefficient. Price series correlation is regarded as a convenient indicator of market integration (see Gilbert (1969),Illori (1968), Cummings (1967), Lele (1967; 1971), Jones (1972), Gupta (1973), Thakur (1974) ) . This approach has been strongly criticised despite its simplicity in the literature on market performance in rural areas (Blyn (1973), Harriss (1979), Heytens (1986), Ravallion (1983; 1986). The studies based on bivariate correlation were found to have involved methodological flaws, the most serious one seems to have occurred due to their failure to recognize the possibility of spurious integration in the process of common exogenous trend (e.g., general inflation), common periodicity (e.g., agricultural seasonality) or auto correlated and heteroscedastic residuals in the regression with non-stationarity price data (for details, see Barrett (1996) and Palaskas and Harriss- White (1993, hereafter PHW).

In the mid-1980s several attempts were made to improve upon earlier methods. The most significant contribution to market integration method came from Ravallion (1986). In order to test alternative hypotheses of market integration, he proposed a dynamic model of spatial price differentials. Although this method mitigates the major methodological limitations of the bivariate correlation method, it still involves serious problems that result in inefficient estimators, which are used for testing alternative hypotheses of market integration and segmentation (see PHW, 1993).

Recent advances in time-series analysis especially those related to cointegration and error correction methods have led to an explosion in the literature on testing for food market integration in many countries including India [See, for example, Asche et. al (1999), Goletti et. al. (1995), Dercon (1995), Alexander and Wyeth (1994), Dahlgram and Blank (1992), Goodwin and Schroeder (1990), Faminow and Bension (1990), Palaskas and Harriss-White (1993), Baharumshah and Habibullah (1994), Behura and Pradhan 1998, Sexton, Kling and Carman (1991) Ghosh,2000].

PHW's study, however, involves methodological defects inherent in the Engle and Granger (1987) method of cointegration. The most undesirable feature of the Engle and Granger (1987) procedure is that the test results may be very sensitive to the choice of the variable selected for normalization (i.e. the left- hand side in the regression). This problem is obviously compounded when there are more than two variables. Moreover, the method does not provide any procedure of testing multiple co integrating vectors when there are three or more variables. Naturally, for conducting the test of market integration properly by the Engle- Granger cointegration method, it is necessary to identify the central (exogenous) and peripheral (endogenous) markets.

A much better way to resolve the problem is to use the multivariate cointegration method developed by Johansen (1988) and Johansen and Juselius (1990). This method treats all the variables as explicitly endogenous and takes care of the endogenity problem by providing an estimation procedure that does not require arbitrary choice of a variable for normalization. It also allows tests for multiple cointegrating vectors.

Much of the literature concerns market integration of food grains. Issues concerning market integration of commercial crops like potato have been inadequately dealt with. The one exception is Palaskas and Harriss-White (1993). However, no work has been done in the way of empirically evaluating potato market integration in West Bengal with the help of recently developed cointegration test by Johansen (1988) and Johansen and Juselius (1990).

Against this backdrop, the objective of the present study is to evaluate empirically spatial integration of potato markets in Hooghly district of West Bengal. In order to do this, it is necessary to compare market prices of potato in one market with prices of comparable varieties among the other markets in the district. To begin, we hypothesised that potato markets are spatially integrated when wholesale and retail prices are taken into consideration. The Maximum Likelihood (ML) method of coitegration test developed by Johansen and Jeselius (1990) has been used to check for market integration.

West Bengal is one of the major potato growing states in India contributing about 35.4 percent of total production in the country in 2001-02. Total production of potato in West Bengal was 78.22 lakh tonnes in 2001-02. It is second largest producer, but state with highest yield during 2001-02. In respect of yield of potato, West Bengal contributed 26 kg per hectare while 18 kg per hectare for all-India level during 2001-02. West Bengal's growth rate of acreage under potato (5.13%) was much higher than that of the country as a whole (3.26%) during 1970-71 to 1997-98. The growth of cold storage industry and the considerable improvements in transport and communication facilities in this period have contributed the increase in area of this crop.

Hooghly is a district where there is a long tradition of potato cultivation with built in infrastructure including credit and marketing facilities. This district occupies the first position both in respect of area, production of potato and the number of availability of cold storages in the State, West Bengal. Percentage share of this district in area under potato in the State was 25.15 during 1998-99 and percentage share of production of potato in the State was 25 during the same period.

The paper is divided into three sections. Section I deals with data, methodology. Section II deals with results and discussion. Section III presents the concluding remarks.

## Section I

## Data and methodology

The data pertaining to the weekly potato prices (both wholesale and retail) were collected from different Marketing Intelligence (MI) centres in the district of Hooghly as assigned by the Directorate of Agricultural Marketing, Government of West Bengal, for the period January 1998 to December 2003. Data on prices pertain to the Friday of each week for twelve months. The price was reported in Rs./quintal. The MI centres selected were Champadanga, Tarakeswar and Sheoraphully.

## Methodology

Before we can conduct cointegration tests, we need to examine the univariate time-series properties of data and confirm that all the price series are non-stationary and integrated of the same order. To test the null hypothesis of non-stationarity against an alternative of stationarity, we have applied Phillips-Perron (PP) tests. The ADF test is a parametric test (predetermined parameters) and it has low power, whereas the PP test statistic is based on a non-parametric modification of the Dickey-Fuller tests. Hence, we give more importance to the PP than ADF test. The test is based on the statistics obtained from applying the Ordinary Least Squares (OLS) method to following regression equation:

$$P_t = \mu + \beta t + \theta P_{t-1} + \sum_{i=1}^{k} c_i \Delta P_{t-i} + e_t \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where $P_t$ is price series; t is time trend;

$\Delta P_{t-i} = P_{t-i} - P_{t-i+1}$ , $e_t \sim$ i.i.d $(0, \sigma^2)$.

To determine whether $P_t$ is non-stationary, the unit root test statistic is calculated. If the unit-root null is rejected for the first difference of the series but can not be rejected for the level, then we say that the series contains one unit root and is integrated of order one, I(1). To test the null hypothesis of non-stationarity against an alternative of stationarity, we have applied Phillips-Perron (PP) tests. After examining the non-stationarity of price series, we test market integration using Johansen and Juselius (1990) cointegration analysis.

Following Johansen and Juselius (1990), the ML method of cointegration may be described here. If $P_t$ denotes an (n×1) vector of I(1) prices, then the k-th order vector autoregressive (VAR) representation of $P_t$ may be written as :

$$P_t = \sum_{i=1}^{k} \Pi_i P_{t-i} + \mu + \beta t + \varepsilon_t ; \qquad (t = 1,2,\text{------------}T)\text{---------------------------}(1)$$

The procedure for testing cointegration is based on the error correction (ECM) representation of $P_t$ given by

$$\Delta P_t = \sum_{i=1}^{k-1} \Gamma_i \Delta P_{t-i} + \Pi P_{t-k} + \mu + \beta t + \varepsilon_t \qquad \text{\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_(3)}$$

Where $\Gamma_i = -(1 - \Pi_1 - \ldots\ldots - \Pi_t)$; i=1,2, …….k-1; $\Pi = -(1 - \Pi_1 - \ldots\ldots\ldots - \Pi_k)$. Each of $\Pi_1$ is an n×n matrix of parameters; $\varepsilon_t$ is an identically and independently distributed n dimensional vector of residuals with zero mean and variance matrix, $\Omega_\varepsilon$ ; μ is a constant term and t is trend . Since $P_{t-k}$ is I(1), but $\Delta P_t$ and $\Delta P_{t-i}$ variables are I(0), equation (2) will be balanced if $\Pi P_{t-k}$ is I(0). So, it is the Π matrix that conveys information about the long-run relationship among the variables in $P_t$. The rank of Π, r, determines the number of cointegrating vectors, as it determines how many linear combinations of $P_t$ are stationary.

If r =n, the prices are stationary in levels. If r=0, no linear combination of $P_t$ is stationary.

If 0<rank (Π)=r<n, and there are n ×r matrices α and β such that $\Pi = \alpha \times \beta'$ , then it can be said that there are r cointegrating relations among the elements of $P_t$ .

The cointegrating vector β has the property that $\beta' P_t$ is stationary even though $P_t$ itself is non-stationary. The matrix α measures the strength of the cointegrating vectors in the ECM, as it represents the speed of adjustment parameters. Two likelihood ratio test statistics are proposed. The null hypothesis of at most r cointegrating vector against a general alternative hypothesis of more than r cointegrating vectors is tested by the

Trace Statistic ( λ - trace) = $-T \Sigma \ln(1 - \hat{\lambda}_i)$ .

The null of r cointegrating vector against the alternative of r+1 is tested by the maximum eigen value statistic (λ – max) = $-T \ln(1 - \hat{\lambda}_{r+1})$ .

$\hat{\lambda}_i$ s are the estimated eigen values (characteristics roots) obtained from the Π matrix, T is the number of usable observations (For details, see, Johansen and Juselius, 1990) . The number of cointegrating vectors indicated by the tests is an important indicator of the extent of co-movement of the prices. An increase in the number of cointegrating vectors implies an increased in the strength and stability of price linkages.

**Section II**

# Results and discussion

The results of the Phillips-Perron test applied to potato prices (wholesale and retail) in the selected markets of Hooghly district of West Bengal are presented in Table 1. Unit root tests have been performed in levels and first difference of these series for all the selected markets of Hooghly district. Testing a null hypothesis of non-stationarity against an alternative hypothesis of stationarity, the results of Phillips-Perron test statistic at levels are shown in the second column of Table 1. The null hypothesis of non-stationarity cannot be rejected even at 10% level for any of the price series of selected markets of Hooghly. Null hypothesis is rejected for all the series using first differences. These results ensured that all the series are non-stationary. From the results of Table 1, we infer that the wholesale and retail prices for selected potato markets in the Hooghly district are integrated of the order 1, i.e., **I** (1).

**TABLE 1** Unit root test for wholesale prices and retail price of potato in different markets of Hooghly district , West Bengal.

| Market | Phillips-Peron (At level) | Phillips-Peron (At first difference) |
|---|---|---|
| WPCH | -2.94* | -14.81* |
| WPSH | -2.96* | -14.40* |
| WPTA | -2.92* | -14.92* |
| RPCH | -2.89* | -17.47* |
| RPSH | -2.99* | -14.70* |
| RPTA | -2.95* | -16.51* |

* Represents the hypothesis significant at 1% level.

**Notes:**

WPCH stands for Wholesale prices of potato in Champadanga market.

WPSH stands for Wholesale prices of potato in Sheoraphully market.

WPTA stands for Wholesale prices of potato in Tarakeswar market.

RPCH stands for Retail prices of potato in Champadanga market.

RPSH stands for Retail prices of potato in Sheoraphully market.

RPTA stands for Retail prices of potato in Tarakeswar market.

Table 2 Cointegration Results for three wholesale markets of potato

| Eigen value($\lambda_i$) | Null hypothesis | Alternative hypothesis | λ-trace value | 95% CV | 90%CV |
|---|---|---|---|---|---|
| | | Trace test | | | |
| 0.172181 | r=0 | r>0 | 44.247 | 35.068 | 32.093 |
| 0.103656 | $r \leq 1$ | r>1 | 19.155 | 20.168 | 17.957 |
| 0.034173 | $r \leq 2$ | r>2 | 4.620 | 9.094 | 7.563 |
| | | λ-max test | λ-max value | | |
| 0.172181 | r=0 | r=1 | 25.092 | 21.894 | 19.796 |
| 0.103656 | r=1 | r=2 | 14.535 | 15.252 | 13.781 |
| 0.034173 | r=2 | r=3 | 4.620 | 9.094 | 7.563 |

Table 2 shows the cointegration results for three wholesale markets, say, Sheoraphully, Champadanga and Tarakeswar in Hooghly district. We have calculated λ-trace and λ-max statistic for showing cointegration of wholesale prices of potato. Now we are interested in the hypothesis that the variables are not cointegrated (r=0) against the alternative of one or more cointegrating vectors (r>0), we calculate λ-trace (0) statistic. Since 44.247 exceed the 95% critical value of λ-trace statistic, it is possible to reject the null hypothesis of no cointegrating vectors and accept the alternative of one or more cointegrating vectors. Next we have used the λ-trace (1) statistic to test the null hypothesis of $r \leq 1$ against the alternative of two or three cointegrating vectors. In this case the value of λ-trace statistic is 19.155. Since this value is less than the 95% critical value of 20.168, we cannot reject the null hypothesis at this significant level.

However, 19.155 does exceed the 90% critical value of 17.957. Therefore, we may reject the null hypothesis and accept the alternative of two or three cointegrating vectors. The λ-trace (2) statistic indicates no more than two cointegrating vectors at both 95% and 90% level of significance.

The second statistics say λ-max tests the null that the number of cointegrating vectors is r against the alternative of r+1 cointegrating vectors. Here the null hypothesis of no cointegrating vectors (r=0) against the specific alternative r=1 is clearly rejected. Because the calculated value λ-max (0,1) = 25.092 exceeds the 95% and 90% critical value. It is noted that the test of null hypothesis r=1 against the specific alternative r=2 cannot be rejected at 95% level, but can be rejected at the 90% level. This shows that the actual data generating process contains only one cointegrating vector. It is also observed that the λ-max (2,3) statistic indicates no more than two cointegrating vectors at both 95% and 90% level of significance.

We may conclude from Table2 that the wholesale prices of potato in different wholesale markets are cointegrated.

Table 3 : Cointegration Results for three retail markets of potato

| | | Trace test | | | |
|---|---|---|---|---|---|
| Eigen value($\lambda_i$) | Null hypothesis | Alternative hypothesis | λ-trace value | 95% CV | 90%CV |
| 0.164402 | r=0 | r>0 | 46.450 | 35.068 | 32.093 |
| 0.126695 | r≤1 | r>1 | 22.582 | 20.168 | 17.957 |
| 0.033955 | r≤2 | r>2 | 4.590 | 9.094 | 7.563 |

λ-max test λ-max value

| | | | | | |
|---|---|---|---|---|---|
| 0.164402 | r=0 | r=1 | 23.868 | 21.894 | 19.796 |
| 0.126695 | r=1 | r=2 | 17.992 | 15.252 | 13.781 |
| 0.033955 | r=2 | r=3 | 4.590 | 9.094 | 7.563 |

Table 3 shows the cointegration result for three retail potato markets, say, Sheoraphully, Champadanga and Trarakeswar in Hooghly district. The result in Table 5 represent that there exists at least one cointegration vector but not more than two on the basis of λ-trace and λ-max statistic values.

It is revealed from Table 2 that the wholesale prices of the three markets are cointegrated and Table 3 shows that retail prices of three markets are also cointegrated. Thus, there is evidence of integration among the selected potato markets of Hooghly district due to close proximity and good communication and infrastructure facilities available in the district.

## Section III

# Conclusion

Coitegration test developed by Johansen and Jeselius (1990) has been used to check for potato market integration. This study utilised the Maximum likelihood (ML) method of cointegration. On the basis of this test it may be concluded that the potato markets (both wholesale and retail markets) are integrated. The results show that there exists a long-run linear relationship between the prices in three selected potato markets in Hooghly district of West Bengal. The special pricing relationships are consistent with market integration and suggesting that the prices provided relevant signals to the selected potato markets in West Bengal. These results have important policy implications. In a situation when potato markets are spatially integrated the government may think of reducing or even withdrawing its efforts to influence the price in the market. The finding of the market integration appears to be quite significant for the success of price policy and market liberalisation programs undertaken in India.

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