Integration of Potato Markets in Bangladesh : A Cointegration Analysis[1]

A S M Anwarul Huq*
Shamsul Alam**

1. Introduction

Marketing of any products is the most important activity to harvest big economic fortunes and to bring prosperity, especially in agricultural sector. In a competitive market the price differences between any two regions or market will be equal to less than transport cost between the two markets and these markets are integrated which means marketing is efficient. The objectives of price stability, rapid economic growth and equitable distribution of goods and services cannot be achieved without the support of an efficient marketing system. Markets that are not integrated may convey inaccurate price information that might distort marketing decisions and contribute to inefficient product movements. In order to determine whether potato prices in a market are in parity with prices in a reference market. So it is necessary to compare market prices of potato in one market with potato prices among other markets in that region.

Price correlation measures the co-movements that underlie the intuitive idea of market integration. The problems are that these co-movements sometimes could not be separated from long-run time trends and seasonality effects. Despite its limitations, price series correlation is the commonly used to measure market integration. However, Ardeni (1989) argued that these approaches ignore the time series properties of price data and the result obtained may be biased and inconsistent. More importantly, the results tend more often to reject the null hypothesis of market integration, indicating that the markets are not efficient although these markets in reality appear to operate competitively.

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1 The paper was derived from the first author's Ph.D thesis entitled " An Analysis of Marketing System of Potato in Bangladesh" .

* Senior Scientific Officer, Agricultural Economics Division, Regional Agricultural Research Station, Bangladesh Agricultural Research Institute, Jamalpur.

** Professor, Department of Co-operation and Marketing; Bangladesh Agricultural University, Mymensingh

Cointegration procedure developed by Granger (1986), and Engle and Granger (1987) is a powerful tool to give a clear answer about the existence or absence of a relation between two economic time series. Although the technique is widely used, its application is extremely limited for the market study in Bangladesh. Goleti *et. al.* (1995) used this technique along with correlation coefficients, long-term multipliers and speed of adjustment in the case of rice markets in Bangladesh. Cointegration test has been used in the present study to show whether potato markets are cointegrated or not. This technique is utilised owing to its superiority over the other.

2. Objective

The objective of the present study is to examine the nature of market integration for potato in Bangladesh.

3. Methodology

3.1 Sources of Data

Present study used potato price data which were collected by the Department of Agricultural Marketing by excluding those areas where non availability of potato price data for many months. Nominal monthly average wholesale potato price for 17 districts namely Dhaka, Chittagong, Rajshahi, Khulna, Comilla, Munshigonj, Jamalpur, Mymensingh, Kishoregonj, Pabna, Bogra, Dinajpur, Jessore, Barishal, Patuakhali, Sylhet and Lakhipur were examined. Sample covers the period from January 1989 to December 1998 generating 120 observations for each of the series.

3.2 Market Integration

Market integration may be defined as a situation which arbitrage cause prices in different markets to move together. More specifically, two markets may be said spatially integrated whenever trade takes place between them and if the price differential for a particular 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 (Behura and Pradhan, 1998 pp.344-346). In a competitive market with free flow information, the price differences between any two regions or markets will be equal to or less than transport cost between the two markets. The market will perform efficiently and there will be no scope for traders to make excessive profits.

3.3 Stationarity

Empirical work based on time series data assumes that the underlying time series is stationary. In regressing a time series variable on another time series variable, one often obtains a very high R^2 although there is no meaningful relationship between the two. This situation exemplifies the problem of spurious regression. This problem arises if both the time series involved exhibit strong trends, the high R^2 observed is due to the presence of the trend, not to a true relationship between the two.

Broadly speaking, a stochastic process is said to be stationary if its mean and variance are constant over time and the value of covariance between two time periods depends only on the distance or lag between the two time periods and not on the actual time at which the covariance is computed. To explain this statement, let P_t be a stochastic time series with these properties:

Mean : $E(P_t) = \mu$

Variance : $var(P_t) = E(Pt - \mu)^2 = {}^2$

Covariance : $\gamma_k = E[(P_t - \mu)(P_{t+k} - \mu)]$

where γ_k, the covariance (or autocovariance) at lag k, is the covariance between the values of P_t and P_{t+k}, that is, between two P values k periods apart. If k =0, we obtain γ_0, which is simply the variance of $P(\sigma=^2)$; if k =1, γ_1 is the covariance between two adjacent value of P.

In short, if a time series is stationary its mean, variance and autocovariance (at various lags) remain the same, no matter at what time we measure them. If a time series is not stationary in the sense just defined, it is called a nonstationary time series (Gujarati, 1994 pp.709-714).

3.4 Unit root and Cointegration Test

Test of stationarity that has recently become popular is known as the unit root test. The easiest way to introduce this test is to consider the following model:

$P_t = P_{t-1} + u_t$ ....(1)

where u_t is the stochastic error term that follows the classical assumptions, namely, it has zero mean, constant variance σ^2, and is nonautocorrelated. Such an error term is also known as a white noise error term. Equation (1) is a first-order, or AR(1), regression in that regress the value of P at time t on its value at time (t

– 1). If the coefficient of P_{t-1} is in fact equal to 1, what is known as the unit root problem, i.e., a nonstationarity situation. Therefore, if run the regression

$P_t = \rho P_{t-1} + u_t$ ....(2)

and actually find that =1, then the stochastic variable P_t has a unit root. In (time series) econometrics, a time series that has a unit root is known as a random walk (time series). And a random walk is an example of a nonstationary time series.

Equation (2) is often expressed in an alternative form as

$\Delta P_t = (\rho - 1) P_{t-1} + u_t$

$= \delta P_{t-1} + u_t$ ....(3)

where $\delta = (\rho - 1)$ and where Δ is the first-difference operator. Note that $\Delta P_t = (P_t - P_{t-1})$. Making use of this definition equation (2) and (3) are the same. However, now the null hypothesis is that $\delta = 0$.

If is in fact 0, equation (3) can be written as

$\Delta P_t = (P_t - P_{t-1}) = u_t$ ....(4)

What (4) says is that the first differences of a random walk time series (= u_t) are a stationary time series because by assumption u_t is purely random.

Now if a time series is differenced once and the differenced series is stationary, the original (random walk) series is integrated of order 1, denoted by I(1). Similarly, if the original series has to be differenced twice (i.e., take first difference of the first difference) before it becomes stationary, the original series is integrated of order 2, or I(2). In general, if a time series has to be differenced d times, it is integrated of order d or I(d). Thus, any time series have an integrated time series of order 1 or greater, that have a nonstationary time series. The terms a stationary process and an I(0) process will use as synonymous.

Under the null hypothesis that $\rho = 1$, the conventionally computed t statistics is known as the τ (tau) statistic, whose critical values have been tabulated by Dickey and Fuller on the basis of Monte Carlo simulations. In the literature the tau test is known as the Dickey-Fuller (DF) test, in honour of its discoverers. Note that, if the null hypothesis that $\rho=1$ is rejected (i.e., the time series is stationary), the usual (Student's) t test can be use. RATS, ET, MICRO, TSP, and SHAZAM, among other statistical packages, give the Dickey-Fuller and MacKinnon critical value of the DF statistic.

For theoretical and practical reasons, the Dickey- Fuller test is applied to regressions run in the following forms:

$\Delta P_t = \delta P_{t-1} + u_t$ ....(5)

$\Delta P_t = \beta_0 + P_{t-1} + u_t$ ....(6)

$\Delta P_t = \beta_0 + \beta_1 t + \delta P_{t-1} + u_t$ ....(7)

where t is the time or trend variable. In each case the null hypothesis is that $\delta = 0$, that is, there is a unit root.

$$\Delta P_t = \beta_0 + \beta_1 t + \delta P_{t-1} + \alpha_i \sum_{k=1}^{N} \Delta P_{t-k} + \varepsilon_t \text{.................................(8)}$$

where, for example, $\Delta P_{t-1} = (P_{t-1} - P_{t-2})$, $\Delta P_{t-2} = (P_{t-2} - P_{t-3})$, etc., that is, one uses lagged difference terms. The number of lagged difference terms to include is often determined empirically, the idea being to include enough terms so that the error term in (8) is serially independent. The null hypothesis is still that $\delta = 0$ or $= 1$, that is, a unit root exists in P (i.e., P is nonstationary). When the DF test is applied to models like (8), it is called augmented Dickey-fuller (ADF) test. The ADF test statistic has the same asymptotic distribution as the DF statistic, so the same critical values can be used, (Gujarati, 1994 pp.718-720).

$$P_{it} = \alpha_0 + \alpha_1 P_{jt} + \varepsilon_t \text{..(9)}$$

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

where, P_i and P_j are price series of a specific commodity in two markets i and j, and ε_t is the residual term assumed to be distributed identically and independently. The constant term $_0$ is left to account for transport and other transfer costs which are assumed to be constant or proportional to price (when the logarithms of the price variables are used, which is the case here) during the sample period. The existence of transport and other transfer costs which vary over time may seriously affect the market integration tests. Ideally, these costs should be subtracted from the prices before applying the testing procedure. However, this is not usually done because the relevant cost data are not available (Zanias, 1999 p.254), which is the case here also.

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).

Once the nonstationarity status of the variables is determined, the next step is to test for the presence of cointegrating (long-run equilibrium) relationship between

$$\Delta P_t = \beta_0 + \beta_1 P_{t-1} + \sum_{k=1}^{N} \delta_k \Delta P_{t-k} + \eta_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (10)$$

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

$$\Delta^2 P_t = \theta_0 + \theta_1 \Delta P_{t-1} + \sum_{k=1}^{N} \phi_k \Delta^2 P_{t-k} + \mu_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (11)$$

where $P_t = P_t - P_{t-1}$ and $_t$ is the residual term. 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 (10) the null hypothesis is H_0 : P_t is I(1), which is rejected in favour of I(0) if β_1 is found to be negative and statistically significant. The above test can also be carried out for the first difference of the variables. That is, we estimate the following regression equation:

where the null hypothesis is H_0:P_t is I(2), which is rejected in favour of I(1) if θ_1 is found to be negative and statistically significant. In general, a series P_t is said to be integrated of order d, if the series achieves stationarity after differencing d times, denoted P_t I(d). Consequently, if P_t is stationary after differencing once then we may denote P_t I(1) and P_t I(0). However, in most applied work the procedure is terminated after the first or second differences.

$$\varepsilon_t = P_{it} - \alpha P_{jt} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (12)$$

Having established that the variables are non-stationary in level, we may then test for cointegration. Only variables that are of the same order of integration may constitute a potential cointegrating relationship. The definition of cointegration used here is that of Engle and Granger (1987) and is defined as follows, consider a pair of variables P_i and P_j, each of which is integrated of order d. Their linear combination, that is, will generally be I(d). However, if there is a constant , α such that ε is I(d-b), where b>0, then P_j and P_i are said to be cointegrated of order d,b and the vector (1,-α) is called the cointegration regression. The relation $P_i = \alpha P_j$ may be considered as long run or equilibrium relation (Engle and Granger,1987), and ε is the deviation from the long-run equilibrium. When P_i and P_j are cointegrated, the long-run relationship P_j - $\alpha P_i = 0$ will tend to be re-established after a stochastic shock. Thus while the individual price series may be characterised by dominant long swings of wander aimlessly, their difference rarely drift from some 'equilibrium' level, that is, they move together in the long-run. However, deviation from the long-run relationship may occur because of delivery lags and other impediments to regional trade.

Comparing equation (9) and (12), equation (12) represents a 'strong-form' test of market integration, where under the null, parameter α_0 should be equal to zero, while α_1 should be equal to one. On the other hand, if α_0 0 and $\alpha_1 = 1$, than the 'weak-form' test for market integration persists (Palakas and Harriss, 1993). However, in most applications, the 'weak-form' test for market integration is usually employed in empirical analysis. This is because information on domestic transportation costs, processing costs, sales taxes, etc., is not available. Therefore, the role of the constant term $\alpha_{0,}$ in equation (9) is to absorb the influence of these factors.

Nevertheless, before we proceed to test for market integration using the approach of cointegration analysis, we need to determine the nature of integration of the variables. According to Granger (1986), a model specified by equation (9) does not make sense unless P_i and P_j are of the same order of integration. Thus a necessary condition for P_i and P_j to be cointegrated is that they must be integrated of the same order. Testing whether the variables are cointegrated in merely another unit root test on the residual in equation (9). The test involved regression the first-difference of the residual lagged level and lagged dependent variables is

$$\Delta\varepsilon_t = \gamma_1\varepsilon_{t-1} + \sum_{k=1}^{N}\varphi_k\Delta\varepsilon_{t-k} + v_t \ldots\ldots\ldots\ldots\ldots(13)$$

Again the test statistics is the t-statistics of γ_1. The critical values are tabulated in Fuller (1976). The null hypothesis is H_0: P_i and P_j are not cointegrated. The null hypothesis is rejected if estimated γ_1 is negative and found to be significantly different from zero. (Behura and Pradhan, 1998 pp.344-330, and Baharumshah and Habibullah, 1994, pp.205-215).

4. Results and Discussion

4.1 Market Integration

The study covers the important potato trading and consumption centres in Bangladesh, namely; Dhaka, Chittagong, Rajshahi, Khulna, Comilla, Munshigonj, Jamalpur, Mymensingh, Kishoregonj, Pabna, Bogra, Dinajpur, Jessore, Barishal, Patuakhali, Sylhet and Lakshipur. Of these seventeen locations capital city Dhaka serves as the central and biggest wholesale market for potato. Being the most populous area in the country and due to its strategic location and communication system with all other districts of the country, Dhaka is the centre of trade in Bangladesh.

For model (10) the values with lags is computed by using computer software RATS. If the computed value of the statistic (i.e., $|\tau|$) exceeds the DF or MacKinnon DF absolute critical values, then we do not reject the hypothesis that the given time series is stationary. If, on the other hand, it is less than the critical value, the time series is nonstationary (Gujarati, 1995 p.719).

Empirical results of the unit root test (ADF) for the hypothesis that potato prices for Dhaka, Chittagong, Rajshahi, Khulna, Comilla, Munshigonj, Jamalpur, Mymensingh, Kishoregonj, Bogra, Jessore, Barishal, Patuakhali, Sylhet and Lakshipur were each individually integrated of order one except Dinajpur and Pabna, against the alternative that they are integrated of order zero, are presented in Table 1. The results for the first-difference of the variables show that the prices are non-stationary in level for all markets. In all cases the null hypothesis $P_t I(2)$ is rejected implying that the series do not require second-differencing to achieve stationarity. We conclude that the potato prices are stationary after differencing once, that they are all I(1) processes.

Given that all potato prices are I(1), we then proceeded to test with the cointegration analysis. Cointegration requires the residuals in equation (3.4.1) to be stationary, that is integrated of zero, I(0). Equation (3.4.5) was estimated in level from using ordinary least squares techniques, Table 4.5.2 shows the results of the testing for cointegration of the markets in Bangladesh. In general, the results yield identical conclusion. Using the ADF-test, all price differences (residuals) are I(0) because the calculated values are less than the critical value. This fulfils the second condition of cointegration. Thus the hypothesis that prices are not cointegrated is rejected in all cases for the sample period of 1989 to 1999. Based on cointegration analysis, it appears that high levels of relationship prevail among the markets. The results in Table 2 implies that regional potato markets in

Bangladesh are spatially linked, that is, the markets are integrated. And integrated markets market means markets are efficient.

5. Conclusion

The empirical results suggest that regional potato markets in Bangladesh are highly cointegrated. This indicates that commodity arbitrage is working. The result also shows that the prices of potato tends to move uniformly across spatial markets and price changes are fully and immediately passed on to the other markets.

With the development of telecommunication facilities price information in one market flow to another distant market within a short time. Government can rely on market forces to supply food from surplus regions to deficit regions. Present study reveals that except Dinajpur and Pabna, potato markets are well integrated in Bangladesh. If effective government intervention is needed to achieve food sufficiency and to remove nutrition deficiency government can adopt centralised and efficient policy.

References

Ardeni, P.G. 1989. Does the Law of One Price Really Hold for Commodity Prices? American Journal of Agricultural Economics, 71(3), 661-669.

Baharumshah, A.Z. and Habibullah, M.S. 1994. Price Efficiency in Pepper Markets in Malaysia: A Cointegration Analysis. Indian Journal of Agricultural Economics, 49(2), 205-216.

Behura, D. and Pradhan, D.C. 1998. Cointegration and Market Integration: An Application to the Marine Fish Markets in Orissa. Indian Journal of Agricultural Economics, 53(3), 344-350.

Engle, R.F. and Granger, C.W.J. 1987. Co-Integration and Error Correction: Representation, Estimation and Testing. Econometrica, 55(2), 251-276.

Fuller, W.A. 1976. Introduction to Statistical Time Series, Academic Press, New York. In - Harris, R.I.D. 1995. Using Cointegration Analysis in Econometric Modelling. Prentice Hall/Harvester Wheatsheaf, London, Great Britain.

Goletti, F., Ahmed, R and Farid, N. 1995. Structural Determinants of Market Integration: The Case of Rice Markets in Bangladesh. The Developing Economics, 33(2), 185-202.

Granger, C.W.J. 1986. Developments in the Study of Cointegrated Economic Variables. Oxford Bulletin of Economics and Statistics, 48(3), 213-228.

Granger, C.W.J. and Newbold, P. 1977. Forecasting Economic Time Series, Academic Press, New York. In Baharumshah, A.Z. and Habibullah, M.S. 1994. Price Efficiency in Pepper Markets in Malaysia: A Cointegration Analysis. Indian Journal of Agricultural Economics, 49(2), 205-216.

Gujarati, D.N. 1995. Basic Econometrics. Third Edition. McGraw-Hill, Inc., New York, USA, 355-714.

Palakas, T.B. and Harriss, B. 1993. Testing Market Integration: New Approaches with Case Material from the West Bengal Food Economy. Journal of Development Studies, 30(1), 1-57. In Baharumshah, A.Z. and Habibullah, M.S. 1994. Price Efficiency in Pepper Markets in Malaysia: A Cointegration Analysis. Indian Journal of Agricultural Economics, 49(2), 205-216.

Zanias, G.P. 1999. Seasonality and Spatial Integration in Agricultural (Product) Markets. Agricultural Economics. 20, 354.

Table 1 : Unit Root Tests for Potato Price Series

Market	Level		First difference	
	Augmented Dickey-Fuller (ADF) test	Lag	Augmented Dickey-Fuller (ADF) test	Lag
Dhaka	-1.3001	11	-5.9637	10
Chittagong	-1.1688	10	-8.8942	9
Rajshahi	-2.1556	11	-9.8331	9
Khulna	-1.6658	12	-9.0511	9
Comilla	-1.2429	13	-3.4862	14
Munshigonj	-1.8521	12	-4.0271	11
Jamalpur	-1.8899	12	-4.3233	11
Mymensingh	-1.3019	11	-2.5745	22
Kishoregonj	-1.2451	10	-10.4562	9
Pabna	-2.6896	13	-3.0977	12
Bogra	-2.0613	12	-8.9012	0
Dinajpur	-5.4437	2	-6.1939	4
Jessore	-1.2938	10	-9.2448	9
Barishal	-1.6074	21	-2.9032	21
Patuakhali	-1.0725	10	-9.3950	9
Sylhet`	-1.2407	10	-8.9983	9
Lakshipur	-1.8676	12	-7.377	10

Note: Critical value of ADF test is available in computer software like – RATS, MICRO TSP, SHAZAM etc., and also in “ W.A. Fuller. 1976. Introduction to Statistical Time Series, John Wiley & Sons, New York (Gujarati, 1995 p.719).

<u>Critical value of ADF test:</u>
1% level of significance = -3.46
5% level of significance = -2.88
10% level of significance = -2.57

Table 2 : Cointegration Test Results of Different Markets

Market	Level	
	Augmented Dickey-Fuller (ADF) test	Lag
Chittagong	-8.3901	0
Rajshahi	-6.0157	1
Khulna	-7.8835	0
Comilla	-8.2858	0
Munshigonj	-8.7004	0
Jamalpur	-7.7080	0
Mymensingh	-10.7649	0
Kishoregonj	-7.3469	0
Bogra	-7.0431	0
Jessore	-7.7005	0
Barishal	-9.0652	0
Patuakhali	-4.1829	5
Sylhet	-6.0401	0
Lakshipur	-7.7145	0

Critical value of ADF test:
1% level of significance = -3.46
5% level of significance = -2.88
10% level of significance = -2.57