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AGRICULTURAL POLICY REFORMS AND SPATIAL INTEGRATION OF FOOD GRAIN MARKETS IN INDIA

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Applying the maximum likelihood method of co-integration, this paper examines the impact of agricultural policy reforms on spatial integration of food grain markets in India. The extent of spatial integration of food grain markets has improved during the post-reform period, as the regional markets, which were either segmented or poorly integrated during the pre-reform period, are found to be strongly integrated, and in most cases to such an extent that satisfies the relative version of the law of one price. The agricultural policy reforms undertaken by the Indian government seem to have contributed towards improving the extent of spatial integration of food grain markets. The results offer important policy implications.

Keywords: Co-integration, Market Integration, Law of One Price, Indian Food Grain Market, Agricultural Reforms
JEL classification: C22, C32, O53, Q11

1. INTRODUCTION

The Indian government has been implementing comprehensive economic reforms involving structural adjustment and liberalisation programmes since 1991. An important component of such programmes is the liberalisation of agricultural commodity markets. Economic liberalisation since the early-1990s led to increasing withdrawal of government intervention from the agricultural commodity sector, which made agricultural prices dependent on the market forces. Jha and Srinivasan (2000) have argued that such liberalisation is required for achieving allocative efficiency and long-term growth in agriculture. Moreover, minimising government interventions in internal and external trade in agricultural commodities and maintaining its role of price stabilisation can yield positive welfare benefits. Government interventions are likely to distort price signals in spatially separated markets because of which agricultural prices

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may not converge efficiently, and regional markets may remain segmented. Such interventions may insulate regional markets from each other and act as barriers to spatial market integration. Liberalisation of agricultural commodity markets is likely to strengthen spatial market integration by removing barriers to movement of commodities across markets, and allowing price signals and information to be transmitted smoothly and the market forces to determine agricultural prices.

If agricultural markets are spatially integrated, producers and consumers will realise the gains from liberalisation. As the correct price signals are transmitted through the marketing channels, farmers will be able to specialise according to long-term comparative advantage and the gains from trade will be realised. Moreover, since integration of markets implies that a deficit or surplus in one market will be transmitted to other markets, an improvement in spatial integration of food markets will ensure regional balance among food-deficit, food-surplus and non-food cash crop-producing regions. Since spatial market integration refers to a situation in which the prices of a commodity in spatially separated markets move together and price signals and information are transmitted smoothly, spatial market integration may be evaluated in terms of a relationship between the prices of spatially separated markets. Since regional level trade flows data on agricultural commodities are not usually available, but the prices of traded agricultural commodities are readily available and generally considered as the most reliable information on marketing system in developing economies, market integration studies have been restricted to the interdependence of prices of spatially separated markets.

The importance of liberalisation for agricultural commodity markets and recent advances in time series econometrics (viz., unit root and co-integration) have generated a lot of interest among researchers in investigating the spatial integration of agricultural commodity markets in many countries (see, for example, Alexander and Wyeth, 1994; Asche *et al*., 1999; Awokuse and Bernard, 2007; Baulch, 1997; Dahlgram and Blank, 1992; Dercon, 1995; Fackler and Tastan, 2008; Faminow and Benson, 1990; Goletti *et al*., 1995; Goodwin and Schroeder, 1991; Ismet *et al*., 1998; Ravallion, 1986; Zanias, 1999).

A few researchers (for example, Dercon, 1995; Ismet *et al.*, 1998) have tried to relate market integration to liberalisation. Dercon (1995) has argued that since the extent of spatial market integration determines the transmission speed of price changes due to any policy reforms across regional markets, the effects of liberalisation and other structural changes in markets should be evaluated not only on the basis of what happens to the prices for producers and consumers but also on the basis of functioning of markets. He has reported that liberalisation had positive effect on the functioning of Ethiopian grain markets through increased short-run integration. Evaluating the performance of Indonesian rice markets, Ismet *et al*. (1998) have argued for limiting government interventions in the integrated markets by rationalising its price stabilisation activities and buffer stock policies, and letting the private sector contribute as much as possible.

Some researchers have evaluated the spatial integration of agricultural commodity markets in India, using advanced time-series methods (see, for example, Ghosh, 2000, 2003, 2008; Jha *et al*., 1997, 2005; Palaskas and Harriss-White, 1993). Very little work has, however, been done to examine the impact of agricultural policy reforms undertaken by the Indian government since the early-1990s on the performance of agricultural commodity markets. However, the importance of such a study can hardly be over emphasised because of its obvious policy implications. The success of agricultural policy reforms in improving spatial efficiency of agricultural commodity markets may be evaluated in terms of their impact on spatial market integration.

This paper evaluates the spatial integration of food grain markets in India during the pre-and post-reform periods. Using the maximum likelihood (ML) method of co-integration due to Johansen (1988) and Johansen and Juselius (1990), it examines whether the agricultural policy reforms since the early-1990s have contributed towards improving spatial integration of food grain markets. Since rice and wheat are the major food crops, and regional level data on monthly prices of these crops are available consistently for a long period, we have confined our analysis to these crops only. After a brief review of agricultural policies, the paper analyses the empirical results obtained from applying the co-integration method, and draws policy conclusions.

2. AGRICULTURAL POLICY REFORMS

Traditionally, Indian agricultural development was based on government interventions in the form of various restrictions on internal and external trade in agricultural commodities. The policies were primarily intended to promote agricultural growth, attain long-term food security and stabilise prices of agricultural commodities. Agricultural price policy was considered a part of the package of policies designed to promote investment and growth in agriculture. Price incentives in the form of support and procurement prices for some crops are offered to farmers to achieve the objectives. Government regulations on internal and external trade in agricultural commodities include licensing requirements and stocking limits for wholesale and retail trade, restrictions on storage, pricing and movement of agricultural commodities across regions, canalisation of trade in agricultural commodities through state trading agencies, quantitative restrictions (QRs) on foreign trade, and high tariffs on imports of agricultural commodities,. The Essential Commodities Act 1955 is the most pervasive Act containing most of the restrictions.

However, these restrictions, by repressing private trading, did not promote competition for fair play of the market forces. The World Bank (1999) has reported that the government's procurement, distribution, and buffer stock programmes have had negative impact of repressing private trading in food grains and undermining its potential contribution to long-term food security. Parikh *et al*. (2003) have argued that these interventions have produced adverse effects on gross domestic product and consumer welfare. This prompted many to argue in favour of the same structural adjustment and liberalisation programmes in agriculture in general and food grains in particular as the Indian government has been implementing in trade, industry and finance since 1991. The World Bank (1999) has proposed that the government should intervene in food grain market only when price fluctuations are outside the desired price-band. It should facilitate smooth operations of the market and should not exercise unnecessary control over it.

The large-scale economic reforms initiated in 1991 have significant implications for agriculture, even though initially the reform process was not much explicit for this sector. The reform process in agriculture was initiated from 1994-95 when India became a part of the multilateral trading system under the World Trade Organisation (WTO). The agricultural policy reforms undertaken by the Indian government since the early-1990s are classified into two categories: (*i*) reform measures liberalising internal market for agricultural commodities, and (*ii*) policy reforms liberalising external trade in agricultural commodities. For a review of the internal and external trade policies and agricultural sector reforms, see Athukorala (2005), Bathla (2006) and Chadha *et al*. (2008).

A series of domestic market reforms have been introduced to improve the efficiency of marketing system and to attract private investment and participation. The Agricultural Produce Marketing Regulations (APMR) Act has been amended. Most of the states have enacted state level APMR Acts. A network of regulated markets has been created to promote organised marketing of agricultural commodities. Changes have been made in the Essential Commodities Act 1955, which regulated internal trade in agricultural commodities. Restrictions on inter-regional movement of farm produce have been relaxed. Licensing requirements and stocking limits for wholesale and retail trade, and selective credit controls used to regulate institutional credit to traders are abolished. State trading activities have been significantly curtailed. Measures have been taken to simplify the regulatory nature of agricultural markets and to allow private sector to contribute as much as possible. Corporate sector has been permitted to enter the agricultural markets through ‘contract farming’, and many domestic and multinational firms are allowed to participate in the marketing and processing of agricultural products. Forward trading has been permitted in many agricultural commodities.

External trade in agricultural commodities has been liberalised in line with the provisions of WTO. During the 1990s, trade policy reforms were undertaken to facilitate greater integration of the agricultural sector with global market. Since 1997, all Indian product lines have been placed under the Generalised System of Preference (GSP). All agricultural products were removed from quantitative restrictions (QRs) and brought under tariff system. The number of agricultural commodities earlier canalised through state trading agencies was reduced, and most of the commodities were brought under Open General Licensing (OGL). Average tariffs on agricultural imports were reduced considerably. Export policies were liberalised to promote export of agricultural commodities through relaxation in export quotas, removal of restrictions on licensing, minimum export price and increased availability of credit.

These policy reforms and the consequent changes in the marketing system are expected to improve the performance of agricultural commodity markets. The reforms in internal and external trade would promote private investment and participation, and improve spatial efficiency of the marketing system. The linkages among regional agricultural markets are likely to be strengthened, and the degree of spatial market integration would improve during the post-reform period.

Since tradability signals the transfer of information regarding market conditions (viz., excess demand or supply) from one market to another as actual or potential trade flows, market integration is usually described in terms of tradability between markets. Spatial market integration, essentially based on trade flows, therefore, includes the market clearance process in which demand, supply and transaction costs in different markets jointly determine the prices, trade flows and the transmission of price shocks from one market to another. Hence, market integration could be viewed as a situation where price signals and information are transmitted to different markets so that the prices in spatially separated markets move together over time. Naturally, any policy that improves the process of trade flows would strengthen spatial integration of markets. Government policies liberalising internal and external trade in agricultural commodities would make trade flows smoother, and allow the market forces to play a greater role in price determination. This would improve the mechanism through which price signals and information are transmitted smoothly across spatially separated markets.

3. METHODOLOGY

Two markets are considered to be spatially integrated if, in the presence of trade between them, the price in importing market (P_{it}) is equal to the price in exporting market (P_{jt}) plus the transport and other transfer costs involved in moving goods between them (T_t). This happens because of the spatial arbitrage condition given by $P_{it} = P_{jt} + T_t$. If the prices are stationary, market integration and the Law of One Price (LOP) can be examined by estimating the regression, $\ln P_{it} = a + b \ln P_{jt} + \varepsilon_t$. The absolute LOP, saying that the prices of a commodity in two different markets are equal and their co-movement is perfect and price changes in the exporting market are transmitted to the importing market on a one-for-one basis, holds when $a = 0$ and $b = 1$. The relative LOP, saying that the prices have a proportional relationship and their levels differ due to factors like transportation and other transfer costs, holds when $a \neq 0$ and $b = 1$.

However, when the prices are non-stationary, co-integration is considered to be an appropriate method for testing market integration and the LOP. This method can be used even in a situation when the co-movement of prices is less than perfect, prices are simultaneously determined and there are seasonal variations in transfer costs. Since co-integration implies that there exists a linear long-run relationship between non-stationary variables in question, the co-integration test for market integration evaluates whether there is a statistically significant linear long-run relationship between different price series. If this relationship exists, then the markets are said to be integrated in general. We have applied the ML method of co-integration to test for market integration. Unlike the Engle-Granger (1987) method of co-integration, the ML method of co-integration allows for testing multiple co-integrating vectors in a multivariate framework. Since this test is carried out in a reduced form vector autoregressive (VAR) model, it does not involve the endogeneity problem caused by simultaneity in price determination, so the test results remain invariant to the choice of a variable for normalisation in the regression.

Under certain condition, the ML method of co-integration, besides providing tests for the general notion of market integration, allows testing for the relative LOP in a bivariate as well as in a multivariate setting. Since this version of the LOP holds for a group of commodity prices when each pair of the prices move proportionally to each other, the multivariate test for it requires that there is only one common stochastic trend in the system, obtained when the prices are pair-wise co-integrated. With n prices in the system, pair wise co-integration requires that there must be $n-1$ co-integrating vectors and hence only one common stochastic trend. In general, with n price series and r co-integrating vectors, there will be $n-r$ different stochastic trends (Stock and Watson, 1988). It may be mentioned that n number of prices can be organised into $n(n-1)/2$ pairs. However, since with n prices one can find at most $n-1$ co-integrating vectors, all but $n-1$ pairs are redundant. Hence, the relative LOP as implied by pair wise co-integration (i.e., when all the price series share a common stochastic trend) is a stronger proposition than the general notion of market integration as implied by the presence of at least one co-integrating vector (and multiple stochastic trends) in a multivariate system. While the relative LOP necessarily implies that markets are integrated, integration of markets does not necessarily satisfy the LOP. This signifies that the number of co-integrating vector is an important indicator of the extent of co-movement of prices. An increase in the number of co-integrating vector implies an increase in the strength of market integration.

Hence, for assessing the impact of agricultural policy reforms on food market integration using the co-integration method, we need to examine the extent of market integration during the post-reform period vis-à-vis the pre-reform one. It is expected that agricultural policy reforms – liberalizing food grain markets, limiting government interventions and allowing the private sector to contribute its best in the markets – would lead to an increase in the extent of market integration. It may, however, be noted that infrastructure development policies for the communication network may help strengthen spatial market integration by reducing transaction costs. Although it is difficult to separate out the individual effects of agricultural and infrastructural policies on market integration, there can be no doubt that agricultural policy reforms in the presence of good communication network would strengthen market integration. From an econometric point of view, this would mean that the number of statistically significant co-integrating vector should be larger in the post-reform period than in the pre-reform one.

3.1. Co-integration Method

The ML method of co-integration, due to Johansen (1988) and Johansen and Juselius (1990), specifies the *k*th order VAR representation of P_t as

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

The procedure for testing co-integration is based on the error correction model (ECM) representation of P_t given by

$$\Delta P_t = \sum_{i=1}^{k-1} \Gamma_i \Delta P_{t-i} + \Pi P_{t-k} + \mu + \beta t + \varepsilon_t \,, \tag{2}$$

where P_t is an $(n \times 1)$ vector of I(1) (i.e., integrated of order one) prices; $\Gamma_i = -(I - \Pi_1 - .... - \Pi_i)$; $i = 1,2,...,k-1$; $\Pi = -(I - \Pi_1 - .... - \Pi_k)$; each of Π_i is an $(n \times n)$ matrix of parameters; ε_t is an identically and independently distributed *n*-dimensional vector of residuals with zero mean and variance matrix, Ω_ε ; μ is a constant term and *t* is trend. Since P_{t-k} is I(1), but ΔP_t and ΔP_{t-i} variables are I(0) (i.e., integrated of order zero), Equation (2) will be balanced if ΠP_{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 co-integrating vectors, as it determines how many linear combinations of P_t are stationary. If $r = n$, the variables are stationary in levels. If $r = 0$, no linear combination of P_t is stationary. If $0 < rank(\Pi) = r < n$, and there are $n \times r$ matrices α and β such that $\Pi = \alpha\beta'$, then it can be said that there are r co-integrating relations among the elements of P_t . The co-integrating 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 co-integrating vectors in the ECM, as it represents the speed of adjustment parameters.

Two likelihood ratio test-statistics are used. The null hypothesis of at most r co-integrating vector against a general alternative hypothesis of more than r co-integrating vectors is tested by

Trace statistic (λ-trace) $= -T \sum_{i=r+1}^{n} \ln(1-\hat{\lambda}_i)$.

The null of r co-integrating vector against the alternative of $r+1$ is tested by

Maximum eigen value statistic (λ-max) $= -T \ln(1-\hat{\lambda}_{r+1})$.

$\hat{\lambda}_i$ s are the estimated eigen values (characteristic roots) obtained from the Π matrix; T is the number of usable observations.

4. DATA AND EMPIRICAL RESULTS

4.1. Database

The data set used in this study consists of monthly wholesale prices of rice and wheat for the period from March 1984 to March 2006. In order to compare the extent of food market integration between the pre- and post-reform periods, we have divided the entire period into two sub-periods. Although the reform process directly related to agriculture were initiated since the mid-1990s, the large-scale economic reforms involving structural adjustment and liberalisation programmes, especially those related to internal and external trade, initiated since July/August 1991, have important implications for agriculture in general and agricultural commodity markets in particular. For this reason, we have considered March 1984 to July 1991 (1984:3 – 1991:7) as the pre-reform period, and August 1991 to March 2006 (1991:8 – 2006:3) as the post-reform one. Since the agricultural policy reforms in the early-1990s were mostly related to internal and external trade in agricultural commodities, their effects would be largely felt in the commodity markets and prices. This is why the policy reforms in the early-1990s are more important relative to those in the mid-1990s from the point of view of market integration. However, since the reform process has been continuous, the effects of agricultural policies during the post-reform period would be reflected in the extent of spatial market integration.

The data on rice and wheat prices quoted at different market centres of the selected states were compiled from various issues of *Agricultural Situation in India*, a monthly journal published by the Directorate of Economics and Statistics, Ministry of Agriculture, Government of India. The choice of the states and the market centres from each state was constrained by the availability of consistent data for the period. The selected states are the major rice/wheat producing states. For rice, we have selected four states: Bihar, Orissa, Uttar Pradesh (UP) and West Bengal (WB). The market centres chosen are: Dumka, Gaya, Jamshedpur, Patna and Ranchi from Bihar; Balasore, Cuttack, Jeypore and Sambalpur from Orissa; Allahabad, Azamgarh, Bahraich, Gorakhpur and

Nowgarh from UP; Contai, Sainthia and Siliguri from WB. For wheat, four states viz., Haryana, Punjab, Rajasthan and UP are selected, and the market centres chosen from each state are: Ambala, Karnal, Rohtak and Sonepat from Haryana; Amritsar, Barnala, Jalandhar and Ludhiana from Punjab; Alwar, Bharatpur, Jaipur, Jodhpur, Kota and Sriganganagar from Rajasthan; Bahraich, Gorakhpur, Jhansi and Kalpi from UP.

For rice market, the price series of the *coarse* variety of rice quoted in Dumka, Gaya, Jamshedpur, Patna, and Ranchi are used for Bihar. The price series of the *coarse* variety reported in Balasore, Cuttack, Jeypore and Sambalpur are used for Orissa. For UP, the price series of the *III/IV-ARWA* variety quoted in Allahabad, Azamgarh, Bahraich, Gorakhpur and Nowgarh are used. Finally, for WB, the price series of the *common* variety quoted in Contai, Sainthia and Siliguri are used. Similarly, for wheat market, the price series of the *Mexican* variety reported in Ambala, Karnal, Rohtak and Sonepat are used for Haryana. For Punjab, the price series of the *WL-711/Kalyan* variety quoted in Amritsar, Barnala, Jalandhar and Ludhiana are used. For Rajasthan, we have used the price series of the *Mexican* variety collected from six market centres viz., Alwar, Bharatpur, Jaipur, Jodhpur, Kota and Sriganganagar. Finally, for UP, the price series of the *Mexican/FAQ* variety quoted in Bahraich, Gorakhpur, Jhansi and Kalpi are used. By choosing the comparable varieties of rice and wheat across market centres and states, we assume that price variability is due to spatial and seasonal effects and not so much due to variety differences.

4.2. Trends in Prices

Figures 1a to 1d in the Appendix present the monthly wholesale prices of rice quoted at different market places in Bihar, Orissa, UP and WB for the entire period covering both the pre- and post-reform ones. Similarly, Figures 2a to 2d in the Appendix display the monthly wholesale prices of wheat quoted at different market places in Haryana, Punjab, Rajasthan and UP. The prices appear to display trending behaviour with upward drifts and seasonal fluctuations. However, from a visual inspection of the time path of the prices, it is difficult to say whether the prices are characterised by deterministic or stochastic trends. It is also difficult to indicate the nature of relationships among the prices. We need to conduct unit root test to check the univariate time-series properties of the prices, and to employ appropriate co-integration test to ascertain the nature of co-movement of the prices during different periods.

4.3. Order of Integration of Prices

As a prerequisite to conducting the co-integration tests, we have evaluated the univariate time-series properties of the data to see whether all the prices are non-stationary and integrated of the same order. We have applied the augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1979, 1981) to all the price series of rice and wheat for the pre- and post-reform periods. The ADF test statistics for the rice and wheat prices in levels and first-difference are reported in Tables 1 and 2, respectively. All the price series are transformed in natural logarithm. The lag length is selected, using the Akaike Information Criterion (AIC). The results show that the null hypothesis of non-stationarity cannot be rejected for the prices in levels but it can be rejected for all the prices in first-differences for the pre- and post-reform periods. The prices are, therefore, non-stationary in levels but stationary in first-differences. This implies that all the series of rice and wheat prices contain a single unit root and are integrated of order one, I(1) for both the periods.

Table 1. ADF Test for Unit Root in the Prices of Rice

Market centre	Pre-reforms (1984:3 – 1991:7)		Post-reforms (1991:8 – 2006:3)	
	Level (τ_τ)	First-difference (τ_μ)	Level (τ_τ)	First-difference (τ_μ)
Bihar: Coarse variety				
Dumka	−3.041 (9)	−4.905 (6)*	−1.226 (2)	−6.948 (2)*
Gaya	−3.061 (2)	−4.561 (9)*	−3.042 (4)	−5.641 (8)*
Jamshedpur	−3.047 (2)	−7.465 (2)*	−2.152 (2)	−7.188 (2)*
Patna	−3.059 (2)	−5.481 (3)*	−2.596 (3)	−8.096 (2)*
Ranchi	−3.074 (5)	−3.738 (8)*	−0.698 (9)	−4.628 (9)*
Orissa: Coarse variety				
Balasore	−3.177 (5)	−4.931 (7)*	−1.737 (4)	−6.144 (4)*
Cuttack	−1.999 (7)	−3.002 (5)**	−0.906 (2)	−7.278 (3)*
Jeypore	−3.163 (7)	−6.998 (8)*	−2.210 (3)	−8.456 (2)*
Sambalpur	−3.146 (3)	−6.013 (4)*	−0.885 (8)	−3.776 (7)*
Uttar Pradesh: III/IV ARWA variety				
Allahabad	−2.073 (2)	−4.971 (3)*	−3.124 (4)	−5.329 (8)*
Azamgarh	−3.132 (3)	−5.432 (2)*	−3.146 (3)	−5.998 (6)*
Bahraich	−3.103 (3)	−4.474 (8)*	−3.127 (2)	−5.064 (9)*
Gorakhpur	−2.332 (8)	−4.557 (9)*	−2.657 (2)	−7.636 (2)*
Nowgarh	−2.481 (5)	−4.194 (8)*	−2.407 (3)	−5.816 (7)*
West Bengal: Common variety				
Contai	−3.086 (4)	−4.742 (9)*	−2.658 (2)	−6.596 (2)*
Sainthia	−3.067 (3)	−6.108 (8)*	−2.601 (2)	−7.727 (2)*
Siliguri	−2.231 (3)	−5.837 (8)*	−1.231 (3)	−6.121 (4)*

Notes: * and ** denote significance at 1% and 5% levels, respectively. Figures in parentheses are the optimal numbers of augmenting lags selected by the Akaike Information Criterion (AIC). The level of significance of the test statistics is determined, using the critical values tabulated by Fuller (1976, Table 8.5.2, p.373).

Table 2. ADF Test for Unit Root in the Prices of Wheat

Market centre	Pre-reforms (1984:3 – 1991:7)		Post-reforms (1991:8 – 2006:3)	
	Level (τ_τ)	First-difference (τ_μ)	Level (τ_τ)	First-difference (τ_μ)
Haryana: Mexican variety				
Ambala	−3.121 (2)	−5.961 (2)*	−3.021 (2)	−6.091 (4)*
Karnal	−2.271 (3)	−3.867 (9)*	−2.485 (2)	−7.957 (2)*
Rohtak	−2.193 (3)	−4.565 (8)*	−1.665 (9)	−5.341 (8)*
Sonepat	−2.153 (3)	−3.729 (7)*	−2.811 (2)	−4.815 (9)*
Punjab: WL-711/Kalyan variety				
Amritsar	−2.219 (3)	−5.706 (4)*	−2.387 (2)	−4.829 (7)*
Barnala	−2.256 (7)	−4.432 (8)*	−2.279 (2)	−6.089 (5)*
Jalandhar	−3.076 (3)	−3.987 (6)*	−0.859 (8)	−5.495 (7)*
Ludhiana	−2.548 (4)	−4.401 (8)*	−1.222 (6)	−6.016 (9)*
Rajasthan: Mexican variety				
Alwar	−3.022 (2)	−6.240 (2)*	−2.864 (2)	−7.634 (2)*
Bharatpur	−2.949 (2)	−5.518 (2)*	−3.012 (2)	−6.144 (4)*
Jaipur	−2.933 (2)	−5.210 (2)*	−2.167 (2)	−5.762 (8)*
Jodhpur	−3.151 (6)	−3.779 (5)*	−2.351 (5)	−7.170 (4)*
Kota	−3.031 (2)	−4.297 (4)*	−3.131 (3)	−6.054 (4)*
Sriganganagar	−3.117 (2)	−5.962 (2)*	−2.473 (2)	−7.413 (2)*
Uttar Pradesh: Mexican/FAQ variety				
Bahraich	−2.489 (2)	−4.929 (5)*	−3.044 (2)	−7.514 (3)*
Gorakhpur	−2.668 (2)	−5.997 (3)*	−2.489 4)	−5.527 (9)*
Jhansi	−2.866 (3)	−6.111 (3)*	−3.127 (3)	−7.322 (3)*
Kalpi	−3.091 (2)	−5.641 (3)*	−2.495 (3)	−5.386 (8)*

Notes: * denotes significance at 1% level. Figures in parentheses are the optimal numbers of augmenting lags selected by the Akaike Information Criterion (AIC). The level of significance of the test statistics is determined, using the critical values tabulated by Fuller (1976, Table 8.5.2, p.373).

4.4. Spatial Integration of Markets

We have investigated the impact of agricultural policy reforms on intra-state as well as inter-state spatial integration of rice and wheat markets.

4.4.1. Intra-State Integration

We have evaluated intra-state spatial integration of these markets by investigating the long-run relationship between the prices of state-specific varieties of rice and wheat quoted at spatially separated locations in each state. The co-integration test results for intra-state spatial integration of rice markets are presented in Table 3. Both the λ-trace and λ-max tests show no significant co-integrating vector and hence no spatial integration of the five regional rice markets in Bihar during the pre-reform period. However, during the post-reform period, both the tests reveal three significant co-integrating vectors, indicating that the regional rice markets are strongly integrated. For Orissa, the λ-trace test shows at most two co-integrating vectors, and the λ-max test shows at most one co-integrating vector for the coarse variety of rice during the pre-reform period. The extent of spatial market integration increased significantly during the post-reform period, as both the tests show three co-integrating vectors and hence one common stochastic trend. The number of common stochastic trends is determined by subtracting the number of co-integrating vectors from the dimension of the impact matrix given by the number of variables (n) included in the VAR. The finding of n-1 co-integrating vectors implies that all the prices share a common stochastic trend and so are pair-wise co-integrated, suggesting that the relative LOP holds for the coarse variety of rice in Orissa during the post-reform period. The results for UP and WB show at most one significant co-integrating vector during the pre-reform period, indicating that the regional rice markets in these states were integrated to an extent. However, the extent of market integration in these states increased greatly during the post-reform period. Both the λ-trace and λ-max tests reveal three significant co-integrating vectors and two common stochastic trends for UP. The results for WB indicate two co-integrating vectors and one common stochastic trend, suggesting that the prices of common variety of rice quoted in three market centres are co-integrated pair wise. This implies that the regional rice markets in WB were so integrated during the post-reform period as to satisfy the relative LOP.

The co-integration results for intra-state spatial integration of wheat markets are reported in Table 4. The results for Haryana, Punjab and Rajasthan show no significant co-integrating vector for the *Mexican/WL-711/Kalyan* variety of wheat marketed in these states in the pre-reform period. The results for UP show one co-integrating vector by the λ-max test and two co-integrating vectors by the λ-trace test for the *Mexican/FAQ* variety of wheat during the pre-reform period. Thus, while the regional wheat markets in UP were spatially integrated to an extent, the regional markets in Haryana, Punjab and Rajasthan were segmented during the pre-reform period. On the other hand, the results for the post-reform period reveal that the extent of spatial integration of wheat markets has increased remarkably in all the four states. The number of co-integrating vector has increased to such an extent that the wheat prices quoted at regional markets in each state contain a common stochastic trend and therefore are co-integrated pair wise. Thus, the regional wheat markets, which were either segmented or poorly integrated during the pre-reform period, are found to be so integrated as to satisfy the relative LOP in all the states during the post-reform period.

Table 3. Co-integration Results for Intra-State Spatial Integration of Rice Markets

Pre-reforms (1984:3 – 1991:7)					Post-reforms (1991:8 – 2006:3)				
Eigen value	Trace test		Maximum eigen value test		Eigen value	Trace test		Maximum eigen value test	
(λ_i)	Null	λ-trace	Null	λ-max	(λ_i)	Null	λ-trace	Null	λ-max
Bihar (k=2 for the pre- and post-reform periods)									
0.255	r=0	70.36	r=0	25.60	0.234	r=0	102.20*	r=0	37.61**
0.246	r≤1	44.76	r=1	24.60	0.183	r≤1	64.59*	r=1	28.48**
0.134	r≤2	20.16	r=2	12.51	0.156	r≤2	36.11**	r=2	23.90**
0.081	r≤3	7.65	r=3	7.34	0.058	r≤3	12.21	r=3	8.43
0.030	r≤4	0.31	r=4	0.31	0.026	r≤4	3.78	r=4	3.78
Orissa (k=2 for the pre- and post-reform periods)									
0.297	r=0	62.77*	r=0	30.73**	0.262	r=0	87.55*	r=0	40.37*
0.212	r≤1	32.05***	r=1	20.68	0.208	r≤1	47.18*	r=1	31.06*
0.121	r≤2	11.37	r=2	11.20	0.113	r≤2	16.12***	r=2	15.93***
0.002	r≤3	0.17	r=3	0.17	0.001	r≤3	0.19	r=3	0.19
Uttar Pradesh (k=2 for the pre- and post-reform periods)									
0.344	r=0	84.81**	r=0	36.73**	0.272	r=0	108.38**	r=0	44.71*
0.227	r≤1	48.08	r=1	22.42	0.190	r≤1	63.67*	r=1	29.72*
0.148	r≤2	25.66	r=2	13.94	0.149	r≤2	33.95*	r=2	22.66*
0.123	r≤3	11.72	r=3	11.40	0.054	r≤3	11.29	r=3	7.77
0.004	r≤4	0.32	r=4	0.32	0.025	r≤4	3.52	r=4	3.52
West Bengal (k=2 for the pre- and post-reform periods)									
0.327	r=0	45.67*	r=0	34.48*	0.183	r=0	46.36*	r=0	28.53**
0.118	r≤1	11.19	r=1	10.96	0.104	r≤1	17.83***	r=1	15.45***
0.003	r≤2	0.23	r=2	0.23	0.017	r≤2	2.38	r=2	2.38

Notes: *, ** and *** indicate significance at 99%, 95% and 90% levels, respectively. The level of significance is determined, using the critical values from Osterwald-Lenum (1992). k=Optimal lag selected by the AIC. The estimated VAR includes a constant and a trend.

The extent of market integration depends on the level of transaction costs determined primarily by transport and communication infrastructure and contract enforcement mechanisms, the degree of perfection of knowledge regarding market conditions and storage facilities. Differences in the extent of market integration across states could be due to regional disparities in infrastructure and institutional structure of markets. Spatial inefficiency of the regional wheat markets in Haryana, Punjab and Rajasthan vis-à-vis UP in the pre-reform period could be due to inadequate transport networks, shortage of storage facilities, lack of competition in the markets, credit constraints limiting private traders' investment in working and long-term capital, and government interventions in various forms. The situation might have changed due to, among other things, agricultural policy reforms, which appear to have improved the spatial integration of wheat markets in all the states during the post-reform period.

Table 4. Co-integration Results for Intra-State Spatial Integration of Wheat Markets

Pre-reforms (1984:3 – 1991:7)					Post-reforms (1991:8 – 2006:3)				
Eigen value	Trace test		Maximum eigen value test		Eigen value	Trace test		Maximum eigen value test	
(λ_i)	Null	λ-trace	Null	λ-max	(λ_i)	Null	λ-trace	Null	λ-max
Haryana (k=1 for the pre- reform period and k=2 for post-reform period)									
0.136	r=0	18.19	r=0	12.29	0.319	r=0	130.29*	r=0	54.23*
0.045	r≤1	5.89	r=1	3.91	0.261	r≤1	76.06*	r=1	42.62*
0.023	r≤2	1.99	r=2	1.99	0.201	r≤2	33.44*	r=2	31.66*
Neg.	r≤3	Neg.	r=3	Neg.	0.013	r≤3	1.78	r=3	1.78
Punjab (k=4 for the pre-reform period and k=2 for the post-reform period)									
0.445	r=0	32.68	r=0	20.02	0.288	r=0	116.32*	r=0	47.96*
0.206	r≤1	12.67	r=1	7.86	0.248	r≤1	68.36*	r=1	40.18*
0.098	r≤2	4.81	r=2	3.52	0.164	r≤2	28.18*	r=2	25.34*
0.037	r≤3	1.29	r=3	1.29	0.020	r≤3	2.84	r=3	2.84
Rajasthan (k=5 for the pre-reform period and k=2 for the post-reform period)									
0.856	r=0	58.21	r=0	23.30	0.669	r=0	283.29*	r=0	156.10*
0.726	r≤1	34.91	r=1	15.55	0.253	r≤1	127.19*	r=1	41.07**
0.544	r≤2	19.36	r=2	9.41	0.225	r≤2	86.12*	r=2	36.00*
0.419	r≤3	9.95	r=3	6.52	0.183	r≤3	50.12*	r=3	28.53**
0.175	r≤4	3.43	r=4	2.32	0.128	r≤4	21.59**	r=4	19.38**
0.088	r≤5	1.11	r=5	1.11	0.015	r≤5	2.21	r=5	2.21
Uttar Pradesh (k=2 for the pre- reform period and k=1 for the post-reform period)									
0.432	r=0	85.03*	r=0	49.27*	0.386	r=0	163.04*	r=0	69.28*
0.209	r≤1	35.76**	r=1	20.39	0.327	r≤1	93.76*	r=1	56.34*
0.133	r≤2	15.37	r=2	12.45	0.231	r≤2	37.42*	r=2	37.36*
0.033	r≤3	2.92	r=3	2.92	0.0002	r≤3	0.04	r=3	0.04

Notes: * and ** indicate significance at 99%, and 95% levels, respectively. The level of significance is determined, using the critical values from Osterwald-Lenum (1992). k=Optimal lag selected by the AIC. The estimated VAR includes a constant and a trend. Neg.=Negligible.

4.4.2. Inter-State Integration

Inter-state spatial integration of rice markets during the pre- and post-reform periods has been investigated by estimating the long-run linear relationship between the prices of the state-specific variety of rice quoted in four markets represented by Allahabad (UP), Balasore (Orissa), Patna (Bihar) and Siliguri (WB). Since the same exercise performed on different combinations of representative markets from each state offered similar results, we have reported the results for inter-state spatial integration among one such combination of the above four rice markets (Table 5). The results reveal only one co-integrating vector and hence three common stochastic trends, suggesting that the Indian rice market system represented by the four markets across states was integrated to an extent during the pre-reform period. The extent of inter-state spatial integration of the rice markets has improved, as the number of co-integrating vector has increased during the post-reform period.

Table 5. Co-integration Results for Inter-State Spatial Integration of Rice Markets

Pre-reforms (1984:3 – 1991:7)					Post-reforms (1991:8 – 2006:3)				
Eigen value	Trace test		Maximum eigen value test		Eigen value	Trace test		Maximum eigen value test	
(λ_i)	Null	λ-trace	Null	λ-max	(λ_i)	Null	λ-trace	Null	λ-max
0.292	r=0	57.67**	r=0	30.03**	0.255	r=0	78.22*	r=0	41.53*
0.189	r≤1	27.64	r=1	18.31	0.142	r≤1	36.69*	r=1	21.62***
0.101	r≤2	9.33	r=2	9.30	0.079	r≤2	15.07	r=2	11.74
0.0003	r≤3	0.03	r=3	0.03	0.023	r≤3	3.33	r=3	3.33

Notes: *, ** and *** indicate significance at 99%, 95% and 90% levels, respectively. The level of significance is determined using the critical values from Osterwald-Lenum (1992). k= Optimal lag selected by the AIC. k=2 for the pre- and post-reform periods. The estimated VAR includes a constant and a trend. The market centres considered are: Allahabad (UP), Balasore (Orissa), Patna (Bihar) and Siliguri (WB). The same exercise performed on different combinations of representative markets from each state offered similar results.

In order to examine whether the extent of spatial integration of wheat markets across states has improved during the post-reform period relative to the pre-reform one, we have estimated the long-run linear relationship between the prices of the state-specific variety of wheat quoted in four representative markets viz., Ambala (Haryana), Ludhiana (Punjab), Jaipur (Rajasthan) and Gorakhpur (UP). The same exercise carried out on different combinations of representative markets from each state provided similar results. Table 6 reports the results for inter-state spatial integration among one such combination of four wheat markets mentioned above. While the λ-max test shows one co-integrating vector, the λ-trace test reveals no co-integrating vector at all during the pre-reform period. However, during the post-reform period, both the tests show three co-integrating vectors and hence one common stochastic trend, suggesting that the prices of wheat in the regional markets across states are strongly integrated. The presence of a common stochastic trend implies that the prices are pair wise co-integrated and the regional wheat markets across states are integrated to such an extent as to validate the relative LOP during the post-reform period.

Table 6. Co-integration Results for Inter-State Spatial Integration of Wheat Markets

Pre-reforms (1984:3 – 1991:7)					Post-reforms (1991:8 – 2006:3)				
Eigen value (λ_i)	Trace test		Maximum eigen value test		Eigen value (λ_i)	Trace test		Maximum eigen value test	
	Null	λ-trace	Null	λ-max		Null	λ-trace	Null	λ-max
0.281	r=0	46.65	r=0	27.78***	0.352	r=0	120.91*	r=0	57.72*
0.150	r≤1	18.87	r=1	13.65	0.227	r≤1	63.18*	r=1	34.35*
0.060	r≤2	5.22	r=2	5.22	0.138	r≤2	28.84*	r=2	23.61*
Neg.	r≤3	Neg.	r=3	Neg.	0.061	r≤3	5.23	r=3	5.23

Notes: * and *** indicate significance at 99% and 90% levels, respectively. The level of significance is determined using the critical values from Osterwald-Lenum (1992). k=Optimal lag selected by the AIC. k=1 for the pre-reform period, and k=2 for the post-reform period. The estimated VAR includes a constant and a trend. The market centres considered are: Ambala (Haryana), Ludhiana (Punjab), Gorakhpur (UP) and Jaipur (Rajasthan). The same exercise performed on different combinations of representative markets from each state offered similar results. Neg.=Negligible.

Overall, the results for intra-state and inter-state spatial integration of rice and wheat markets indicate that the extent of integration improved remarkably during the post-reform period relative to the pre-reform one. The regional markets, which were either segmented or poorly integrated during the pre-reform period, are found to be strongly integrated, and in most cases to such an extent that satisfies the relative LOP during the post-reform period. While the relative LOP holds for rice markets in two states, it holds for wheat markets in four states. It also holds for wheat markets across states. The agricultural policy reforms since the early-1990s appear to have contributed towards improving the extent of spatial integration of food grain markets.

5. SUMMARY AND POLICY CONCLUSIONS

Applying the maximum likelihood method of co-integration, we have investigated the impact of agricultural policy reforms on spatial integration of rice and wheat markets in India. The results indicate that the extent of intra- and inter-state spatial integration of these markets has improved during the post-reform period relative to the pre-reform one. The regional markets, which were either segmented or poorly integrated during the pre-reform period, are found to be strongly integrated, and in most cases to such an extent that satisfies the relative LOP during the post-reform period. The agricultural policy reforms since the early-1990s seem to have contributed towards improving the extent of spatial integration of food grain markets, lending support to the argument for market liberalisation and minimisation of government interventions in the food grain economy. Further liberalisation would strengthen spatial integration of markets.

Since the effects and incentives of different policies will be transmitted smoothly to all regional markets in an well integrated market system, the government could promote growth in production and ensure price stability with lower costs of operation by suitably designing price policy and rationalising its activities in the food grain economy and allowing private traders to contribute as much as possible in the market. As the correct price signals are transmitted smoothly to all the markets, producers will be able to take appropriate decisions on input purchase, production, sale, storage, etc. Consumers will also be benefited, as the well-integrated market ensures availability of food grains and stability in prices at the regional level. The Bangladesh famine in 1974 has often been explained in terms of highly volatile food prices causing dramatic declines in food entitlements for households dependent on markets for their food supply (Quddus and Becker, 2000). Our results suggest that in well-integrated food markets, this type of famine could be avoided by suitably designing agricultural price policy and rationalising government activities (such as buffer stock and public distribution of food grains) in the food economy.

The degree of market integration depends not only on agricultural policy reforms but also on the level of transaction costs determined primarily by transport and communication infrastructures, storage facilities, and contract enforcement mechanisms. The government could promote agricultural growth and ensure stability in food grain prices by limiting its direct intervention in the agricultural markets, but increasing its attention to improve physical and institutional infrastructures. Reliance on direct intervention of the government in the markets can be reduced significantly, if the government promotes efficient trading of agricultural commodities by liberalising the markets, improves the transport and communication networks, and provides storage facilities and short- and long-term finances to private traders.

APPENDIX

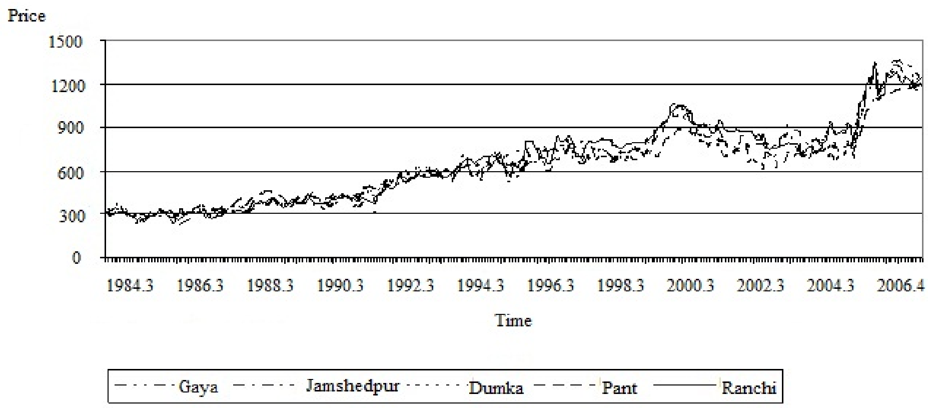

Figure 1a. Behaviour of Rice Prices (Rupees per Quintal) in Bihar

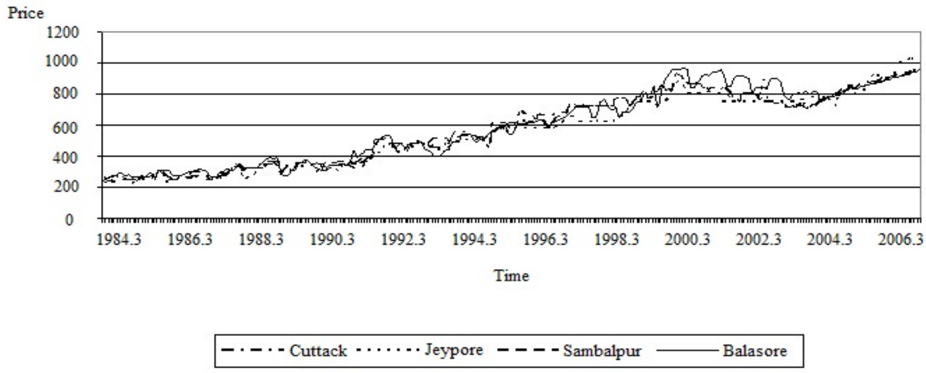

Figure 1b. Behaviour of Rice Prices (Rupees per Quintal) in Orissa

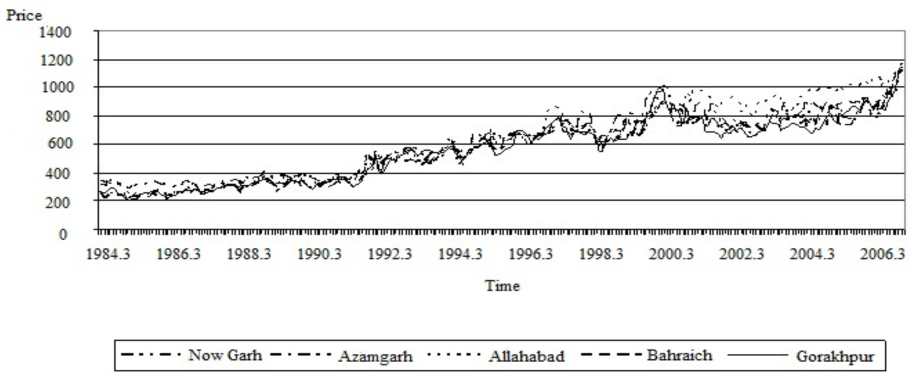

Figure 1c. Behaviour of Rice Prices (Rupees per Quintal) in Uttar Pradesh

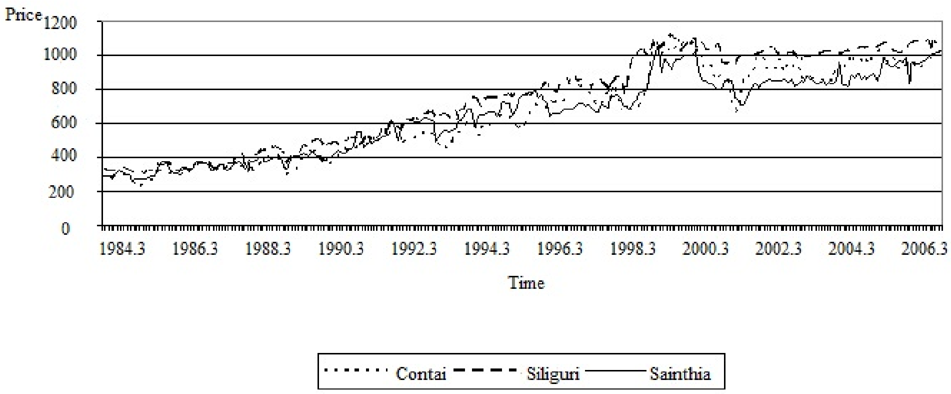

Figure 1d. Behaviour of Rice Prices (Rupees per Quintal) in West Bengal

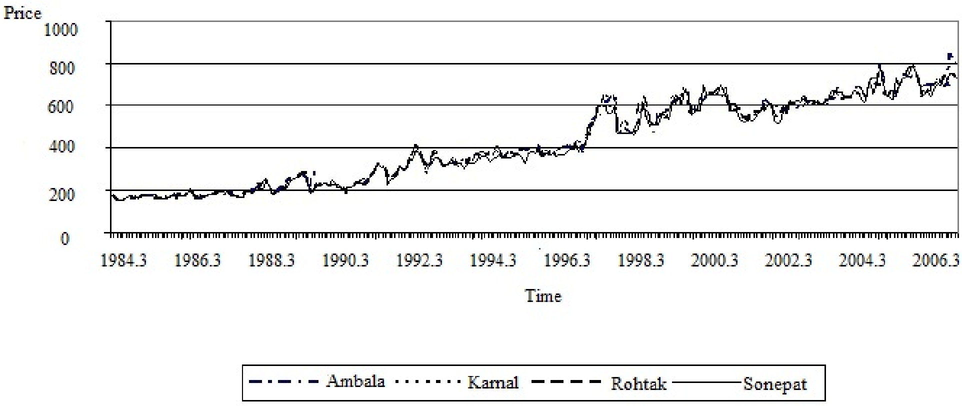

Figure 2a. Behaviour of Wheat Prices (Rupees per Quintal) in Haryana

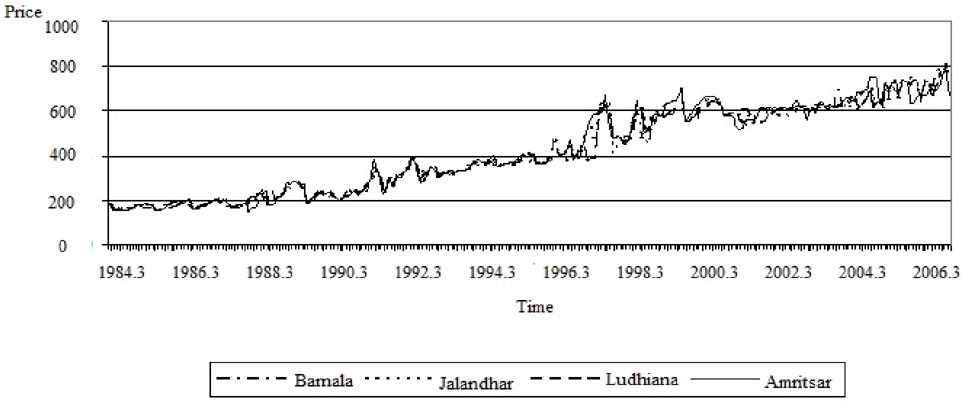

Figure 2b. Behaviour of Wheat Prices (Rupees per Quintal) in Punjab

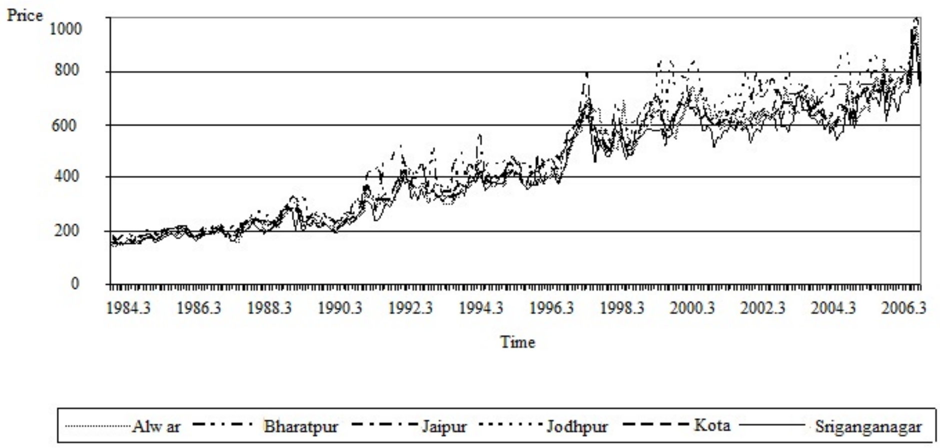

Figure 2c. Behaviour of Wheat Prices (Rupees per Quintal) in Rajasthan

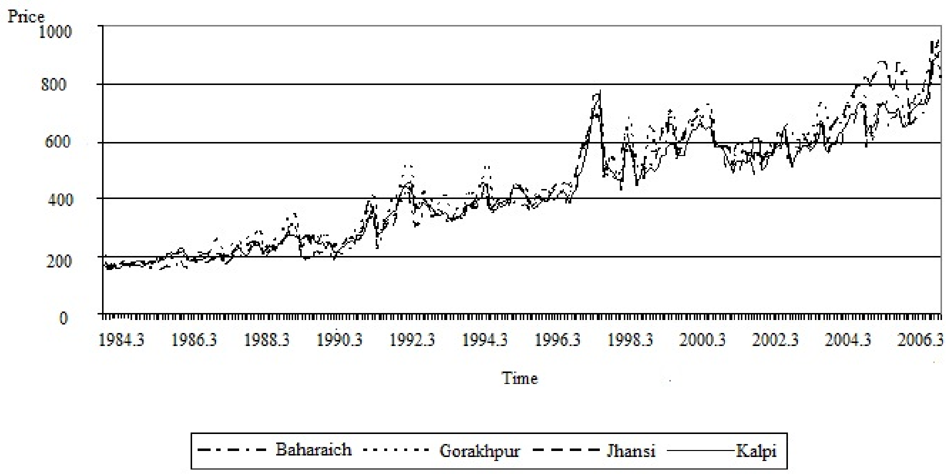

Figure 2d. Behaviour of Wheat Prices (Rupees per Quintal) in Uttar Pradesh

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