P-ISSN: 2618-0723
E-ISSN: 2618-0731

NAAS Rating: 5.04
www.extensionjournal.com

International Journal of Agriculture Extension and Social Development

Volume 7; Issue 12; December 2024; Page No. 430-436

Received: 06-10-2024
Accepted: 05-11-2024

Indexed Journal
Peer Reviewed Journal

Spatial integration of major wholesale potato markets of India: A cointegration analysis

[1]Prashanth J, [2]Vijayakumar JS and [3]Indumathi M

[1-3] Ph.D. Scholar, Department of Agricultural Economics, University of Agricultural Sciences, Dharwad, Karnataka, India

DOI: https://doi.org/10.33545/26180723.2024.v7.i12g.1448

Corresponding Author: Prashanth J

Abstract

Agricultural price policy in emerging countries like India, is heavily influenced by the level of market integration for agrarian products mainly due to perishability, seasonality, and uncertainty in production, potato prices will remain unstable therefore, market efficiency can be accomplished by using market integration. The current study examines the market integration by using cointegration analysis on the monthly wholesale prices of potatoes in four significant Indian markets, encompassing 168 observations, from January 2010 to December 2023. To assess stationarity in the present study both Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests were used, to assess cointegration and the relationship of the direction between market. Johansen's cointegration test and the Granger causality test were employed. The results revealed price series were to remain stationary at the level itself, and the Johansen cointegration test revealed the presence of integration among the markers that were chosen because at least one cointegrating equation was present. The Granger test revealed, unidirectional causalities between market pairs such as Indore-Agra, Burdwan-Ahmedabad, Indore-Ahmedabad, and Indore-Burdwan and bidirectional relationships between market pairings such as Ahmedabad-Agra and Burdwan-Agra. The coefficient of the error correction term revealed that about 31.1 per cent adjustment towards the long-run equilibrium in the Agra market occurs in a one-month time period.

Keywords: Cointegration, potato, stationarity, markets

Introduction

Farmers and consumers did not directly benefit from trade liberalization unless agricultural product markets were geographically connected (Basu, 2006) [2]. Farmers won't be able to specialize by their sustained comparative advantage, the benefits of trade won't materialise and the proper price signals won't be conveyed through market channels if markets are not integrated. Agricultural marketing plays a vital role in moving commodities from the producer to the consumer and in keeping prices stable. Marketing plays a vital part in economic growth because it promotes productivity, minimizes production costs, and eliminates excessive fluctuations in output and pricing (Kumar *et al.*, 2018) [8]. However, to accomplish these benefits, the marketing system and marketing technology must keep up with the country's industrial technology and socio-economic growth. The presence of a higher degree of integration between markets is one of the typical signs of efficient market systems.

Market integration occurs if prices of different markets at different geographical locations of related goods follow similar trends over a long period. Market integration is an indicator that will explain how much different markets are related to each other (Rani *et al.*, 2017) [10]. Through the transmission of price signals and other information, market integration will be a useful strategy for improving market efficiency. This can lead to price stabilisation, which may then spread to other markets (Ghafoor *et al.*, 2009) [5].

Thereby, a proper study on market integration is required to understand the co-movements of prices and the smooth transmission of information and price signals across spatially separated markets (Venujayakanth *et al.*, 2017) [15], especially while dealing with bulk volume and highly perishable products. One measure of the existence of efficient market functioning is a high degree of market integration. Market integration is a necessary condition for stabilizing prices across regions (Mukim *et al.*, 2009; Saha *et al.*, 2019) [9, 12] and, thereby, can help in realizing both producer and consumer surpluses.

Potato is one of the most significant non-cereal crops in the world's, high-yielding horticultural food crop. It began as a significant cool-season crop in both the lowlands and the highlands. However, it is currently grown in practically every Indian state under various agroclimatic circumstances. At the time of the inception of ICAR-CPRI in 1949, India produced 1.54 million tons of potatoes from an area of 0.234 million ha with an average productivity level of 6.58 t/ha. The estimated domestic demand for potatoes in India is 122 million tons by 2050.

Methodology

The monthly wholesale modal prices of potatoes of four major markets comprising 168 observations between January 2010 to December 2023 in India *viz*. Agra (Uttar

Pradesh), Burdwan (West Bengal), Ahmedabad (Gujarat), and Indore (Madhya Pradesh) were employed in the present study. All the markets were selected according to the following criteria: (i) Largest average volume of arrivals during January 2010 to December 2021 and (ii) The availability of price and arrival data throughout the study period without any break. The price and arrival data of the markets were sourced from the agricultural marketing portal of GoI (AGMARKNET, 2023) [1].

Stationarity

Before testing the cointegration, observations must be stationary (*i.e.*, the time-independent series with constant mean, constant variance, and autocorrelation). In the present study, all the market price data sets were made stationary before attempting integration and forecasting-related analysis. As the monthly price series was used in the present study, it has to be ensured that the prices need to be integrated at the same order or level, co-integration cannot be tested otherwise if the order of integration between the markets is found to vary.

Lag selection test

A stationary data series may be devoid of any trend, but the existence of autocorrelation cannot be overruled. It has to be made sure that up to which number of lags the data series is not significantly auto-correlated. Only then, it can be assured that the given data series is completely stationary and fit for further analysis. Deriving optimal length is an essential part of co-integration analysis. The most commonly used lag length selection criteria were the Akaike Information Criteria (AIC) and the Schwartz Information Criteria (SIC) which consider the following specifications as given below.

$$\mathbf{AIC = -2\left(\frac{LL}{T}\right) + \frac{2t_p}{T}}$$

$$\mathbf{SBIC = -2\left(\frac{LL}{T}\right) + \frac{\ln(T)}{T}t_p}$$

$$\mathbf{HQIC = -2\left(\frac{LL}{T}\right) + \frac{2\ln\{\ln(T)\}}{T}t_p}$$

Where t_p the total number of parameters in the model and LL is the log-likelihood.

As the fit of the model improves, the AIC and SIC will approach - ∞. Ideally, the AIC and SIC were as small as possible (note both can be negative). But since ln (T) will always be greater than 2, the SIC is preferred to be the more appropriate lag length compared to AIC.

Stationarity test

Following lag selection, the monthly wholesale potato prices were tested for stationarity by using below below-mentioned tests.

- Augmented Dickey-Fuller test,
- Phillips-Perron test.

Augmented Dickey-Fuller test (ADF test)

The ADF test investigates the null hypothesis that $\delta_i = 0$ and the alternative hypothesis of the ADF test is $\delta_i < 0$. The series will be considered non-stationary if the null hypothesis for the test cannot be rejected. If Y_t is found non-stationary at levels *i.e.* I(0) then it was determined whether it is stationary at 'n' differences *i.e.* $Y = (Y_{it} - Y_{it-1}) \sim I(n)$ by using the specification given below:

$$\mathbf{\Delta Y_{it} = \alpha + \beta_i T + \delta_i Y_{it-1} + b_i \sum_{i=1}^{p} \Delta Y_{it-1} + e_t}$$

Where,

Y_{it} = Monthly potato price in a given market 'i' at a time't';

$\Delta Y_{t-i} = Y_{t-1} - Y_{t-2}$ (t-i – lagged prices and Δ – differenced series);

T = Time trend;

α = Drift parameter;

P = Lag length selected based on Schwartz information criterion (SIC)

β_i, δ_i and b_i = Coefficients; and

e_t = Pure white noise error-term.

Phillips-Peron Test (PP Test)

It is a modification over the ADF test statistic which considers the less restrictive nature of the error process and is given as,

$$\mathbf{\Delta Y_{it} = \alpha + \delta_i Y_{it-i} + e_t}$$

Where,

Y_{it} = Monthly wholesale potato price in a given market 'i' at a time "t"

α and δ_i = Coefficient; and

ε_t = Pure white noise error-term

Co-integration analysis

Co-integration testing depicts the long-term relationship between variables. Depending upon the order or level at which the stationary is attained; the co-integration analysis was used to work out for estimating long-term price transmission and market integration therein. If the stationary is reached at level itself (i.e. I=0) then the Engle-granger method was used, Johansen co-integration test will be used if the stationary is achieved for the market pairs at the differencing (I >1), (Johansen and Juselius, 1990) [6].

Johansen's Cointegration test

Johansen and Juselius (1990) [6] formulated a general framework for examining multiple cointegrating vectors, which allows the estimation of all possible cointegrating relationships between the variables. It determines the long-run association or relationship between the markets which are spatially located. The study used the tests of the following model.

$$\Delta P_t = \mu + \sum_{t=1}^{\rho-1} \tau_t P_{t-1} + \pi P_{t-1} + \epsilon_t$$

Where, Pt denotes an (n×1) vector of I(1) prices, Γ = -(I-Π1 - ...- Πt); i=1, 2,…., ρ - 1; ρ is the lag order of auto-regressive process, Π = -(I - Π1 - ...- Πρ). Each of Πi is an n×n matrix of parameters; εt is the white noise error term. 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. There are two types of test ratios *viz.*, trace test and maximum eigenvalue test to be followed to determine the cointegration. The null hypothesis for the trace test is that the number of cointegration vectors is r = r* while the alternative hypothesis is that r > r*. On the other hand, the null hypothesis for the "maximum eigenvalue" test is as for the trace test but the alternative is r = r* + 1 (Reddy, 2012) [11].

Granger causality test

To show the causal relationship between the time series in certain markets, the Granger causality test can be helpful. If variable Y is granger-caused by variable X, it means that the values of variable X support the prediction of variable Y's values, and *vice versa*. The causality test was conducted within the vector auto regression (VAR) model framework and it helps to test the long-run causal relationship and direction of a relationship among the markets. Using bivariate VAR, the causation relationship between the two market pairs was determined using the ordinary least square (OLS) equation as given below:

$$\ln X_t = \sum_{i=1}^{m} \alpha_i \ln X_{t-1} + \sum_{j=1}^{m} \beta_j \ln Y_{t-j} + e_{1t}$$

$$\ln Y_t = \sum_{i=1}^{m} \alpha_i \ln Y_{t-1} + \sum_{j=1}^{m} \beta_j \ln x_{t-j} + e_{2t}$$

Where,
X and Y = Two different price series
ln = Price series in logarithm form
T = Time trend variable

The subscripts stand for the number of lags of both variables in the setup. The null hypothesis in both equations is that ln X_t does not Granger-cause ln Y_t. The rejection of the null hypothesis implies the presence of Granger causality between the variables.

Error correction model

Once the long-term equilibrium in the market pairs has been confirmed, there is a possibility of short-run disequilibrium which means that price changes in one market may not be instantly conveyed to the other market and may take some time. Accordingly, the speed of short-run adjustment to the long-run equilibrium was determined by using the Error Correction Model (ECM) as mentioned below.

$$\Delta Y_{t-i} = \alpha_0 + \alpha_1 \Delta X_{t-i} + \alpha_2 \, e_{t-1} + \varepsilon_t$$

Where,
ΔY_{t-i} = Price of potato in the market 'Y';
ΔX_{t-i} = Price of potato in the market 'X';
α_0 = Constant term;
α_1, α_2 = Speed of price transmission;
e_{t-1} = Lagged error term of the co-integration model; and
ε_t = White noise error-term.
The magnitude of α_2 explains the speed at which the price approaches equilibrium and it is anticipated to be negative so that the equilibrium is restored in the long run.

Results and Discussion

A graphical representation of monthly wholesale price series data of major potato markets of India is furnished in Figure 1. The time plot of selected markets showed that the price series of all the selected markets are moving in the same pattern this reveals that there is a presence of market integration among the major selected markets.

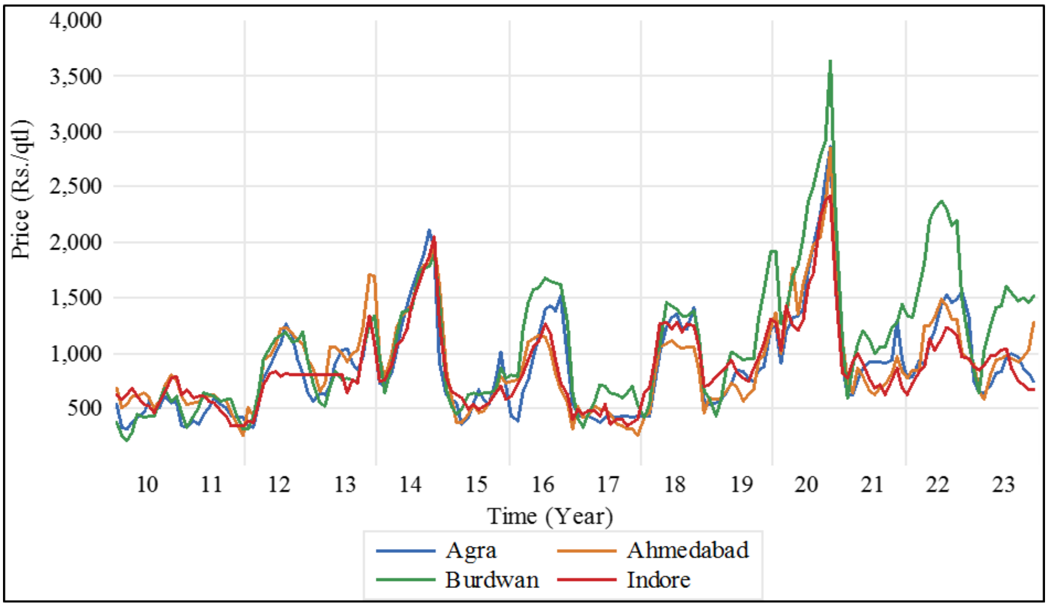

Fig 1: Time plot of potato prices of selected markets (January 2010-December 2023).

The summary statistics of monthly wholesale market prices of potatoes for major selected markets spanning from January 2010 to December 2023 are presented in Table 1. The results revealed prices showed an asymmetric pattern of distribution in all the major selected markets with the highest and lowest average prices found to be in Burdwan (Rs.1082.70/qtl) and Indore (Rs. 865.62/qtl). The maximum price is recorded in the Indore market (5412.50/qtl) and the minimum price is observed in Burdwan with Rs.216.20/qtl. Selected potato markets exhibited positively skewed distribution means most of the observations are falling on the left side of the mean value and towards the right larger values. All the selected markets' prices are showing leptokurtic behavior which means that prices are narrowed than normal distribution.

Table 1: Descriptive statistics of wholesale potato prices (Rs. /qtl) of the selected market for a period from January 2010 to December 2013, N=168

Markets	Agra	Ahmedabad	Burdwan	Indore
Mean	879.41	903.12	1082.70	865.62
Median	798.29	828.97	992.10	804.01
Maximum	2858.75	2847.05	3625.23	5412.5
Minimum	314.61	250.00	216.20	335.86
SD	451.89	431.99	589.70	377.50
Skewness	1.39	1.30	1.12	1.53
Kurtosis	2.69	2.44	1.74	3.42

Note: SD-Standard Deviation

Correlation analysis

The degree of connection between the chosen markets throughout the study period can be ascertained using a zero-order correlation matrix (Conventional techniques). The findings of the correlation matrix are shown in Table 2 it reveals that all the selected potato markets showed a strong positive association or correlation among them, the correlation coefficient (r) values ranging from 0.83 to 0.90 which indicates that all the selected potato markets are moving together that the price difference in the markets is not greater than the cost of transportation, and hence the markets were efficient in their operation. The study findings are in line with study findings by Swaminathan *et al.* (2022) reported a highly positive association among the potato markets.

Table 2: Zero order correlation matrix for monthly potato prices between major selected markets of India (2010 to 2023)

Particulars	Agra	Burdwan	Ahmedabad	Indore
Agra	1.00			
Burdwan	0.88***	1.00		
Ahmedabad	0.88***	0.85***	1.00	
Indore	0.90***	0.83***	0.90**	1.00

Note: *** indicate significance at 1per cent

Stationarity

Before testing cointegration among the market's series must be stationary *i.e.*, the time-independent series with constant mean, constant variance, and autocorrelation. Augmented Dickey-Fuller test (ADF test) and Phillips-Perron test (PP test) were employed in the present study to check the stationarity same as been furnished in Tables 3 and 4. In the case of stationarity testing the null hypothesis of non-stationarity against an alternative of stationarity of the time series for both Augmented Dickey-Fuller and Phillips-Perron. All the price series data were transformed into natural logarithms. The findings of ADF and PP revealed that statistic values exceed the critical values the null hypothesis of non-stationarity rejected at 1, 5, and 10 per cent levels of significant respectively implies that price series are stationary at the level itself and free from the consequence of differencing. The findings are in line with Devi *et al.* (2015) [3] and Katoch and Singh (2020) [7] who also reported price series are stationarity at level.

Table 3: Estimates of Augmented Dickey-Fuller (ADF) test for monthly prices of selected Potato markets

Markets	ADF test results at the level		
	t-statistic	Probability	Remarks
ln Agra	4.96***	0.0000	Stationary
ln Ahmedabad	3.71***	0.0047	Stationary
ln Burdwan	4.88***	0.0001	Stationary
ln Indore	3.66***	0.0055	Stationary

Note: 1. *** indicates significance at 1 per cent, 2 The critical values are -3.46(1%), -2.88(5%) & -2.57(10%).

Table 4: Estimates of Phillips-Perron test (PP) test for monthly prices of selected Potato market

Markets	PP test results at the level		
	Adj t-statistic	Probability	Remarks
ln Agra	3.50***	0.0091	Stationary
ln Ahmedabad	3.00**	0.0362	Stationary
ln Burdwan	2.83*	0.0559	Stationary
ln Indore	3.06**	0.0312	Stationary

Note: 1. *, **, *** indicate significance at 10%, 5%, and 1% respectively
2. The critical values of test statistics are -3.49(1%), -2.88(5%) and -2.57(10%)

Lag selection

The lag length selection is a prerequisite for conducting a cointegration analysis, the Granger causality test, and the Vector error correction model. Generalized VAR-based analysis is conducted for the selection of lag lengths and the same has been furnished in Table 5. The lowest values of the AIC, SIC, and HQIC were found at lag two in selected markets that were chosen.

Table 5: VAR-based lag length selection in all the selected potato markets

Lag	AIC	SIC	HQIC
0	0.46	0.53	0.49
1	-3.57	-3.19	-3.42
2	-3.95*	-3.26*	-3.67*
3	-3.94	-2.94	-3.54
4	-3.89	-2.59	-3.36
5	-3.87	-2.25	-3.21
6	-3.76	-1.84	-2.98
7	-3.63	-1.40	-2.73
8	-3.56	-1.03	-2.53

Note: 1. AIC-Akaike Information criterion, SIC – Schwarz Information Criterion and HIQ- Hannan-Quinn Information Criterion
2. *- Denote lag length selected by a criterion

Cointegration analysis

The co-integration between the chosen price series of potato markets that were chosen was tested using the Johansen-Juselius maximum likelihood procedure to see if there was a short- and long-term relationship between the price series of markets that were chosen in India after it was confirmed that the price series were stationary at the level itself as same as been presented in Table 6 and 7. The Johansen approach was applied in three stages for potato markets: first, the suitable lag length was selected based on lag length criteria. Secondly, the PP and ADF tests were used to verify the integration order. In the last phase, the cointegration was examined using the trace and max Eigen statistics of Johansen's method, which is based on the vector autoregressive model (VAR). To test the long-run relationship, the null hypothesis of the trace test and maximum eigenvalue test is no integration ($r = 0$) with a contrasting alternative hypothesis ($r \geq 1$) of at least one cointegrated equation prevailed in the VAR system. The presence of at least one cointegrating equation indicates that the markets are well integrated with the price transmissions across the markets to ensure efficiency. Results from the table showed that trace and Maximum Eigenvalues were found higher than the 5 per cent critical values in at least one equation and led to the acceptance of the alternative hypothesis of the presence of cointegration among the selected markets. The existence of a cointegrating vector suggests that wholesale potato markets in India have an equilibrium relationship over the long term. This perspective presupposes that there is information flow, or price transmission, among the parties involved. The present study findings corroborate with findings of Dey *et al.* (2021) [4] observed that three main wholesale potato prices showed a long-term equilibrium among them.

Table 6: Unrestricted co-integration rank test (trace) in selected potato markets of India

H0	HA	Trace statistics	Critical values at 5 per cent	Probability
$r = 0$	$r \geq 1$	82.70*	47.85	0.0000
$r \leq 1$	$r \geq 2$	32.76*	29.79	0.0221
$r \leq 2$	$r \geq 3$	16.96*	15.49	0.0298
$r \leq 3$	$r \geq 4$	7.35*	3.84	0.0067

Note: 1. Trace test indicates 4 cointegrating equations at the 0.05 level, 2.* denotes rejection of the hypothesis at the 0.05 level, 3. ** Mackinnon-Haug-Michelis (1999) p-values

Table 7: Unrestricted co-integration rank test (Maximum eigenvalue) in selected potato markets of India

H0	HA	Maximum Eigen-value statistics	Critical values at 5 per cent	Probability
$r = 0$	$r \geq 1$	49.94*	27.58	0.0000
$r \leq 1$	$r \geq 2$	15.79	21.13	0.2368
$r \leq 2$	$r \geq 3$	9.61	14.26	0.2387
$r \leq 3$	$r \geq 4$	7.35	3.84	0.0067

Note: 1. Maximum eigentest indicates 1 cointegrating equation at the 0.05 level, 2.*denotes rejection of the hypothesis at the 0.05 level, 3. ** Mackinnon-Haug-Michelis (1999) p-values

Granger causality test: Granger causality was examined between the chosen pairs of potato markets because there must be causality in at least one direction if there is a co-integration between the prices of two marketplaces (Shami *et al.*, 2020) [13]. Granger's causality illustrates the direction of price transmission across the two market places and associated arbitrage is, the actual movement of a good to make up for price discrepancies, and the findings of the causality test are shown in Table 8. Based on the lowest AIC, an ideal lag length of two is chosen. Results showed that a bidirectional relationship exists between market pairs *viz.*, Ahmedabad-Agra and Burdwan-Agra it implies that each pair's price change in the former market contributes to the formulation of the wholesale price in the latter, while price change in the latter feedback by the price change in the former market. Furthermore, unidirectional causalities between market pairs *viz.*, Indore-Agra, Burdwan-Ahmedabad, Indore-Ahmedabad, and Indore-Burdwan implies that the price change in the former market in each pair granger causes the price formation in the latter market, while the price change in the latter market is not feedback by the price change in the former market.

Table 8: Results of pair-wise granger causality in selected potato markets of India

Null hypothesis	F-Statistics	Prob.	Granger cause	Direction
Ahmedabad does not granger cause Agra Agra does not granger cause Ahmedabad	5.96 7.80	0.0032 0.0006	Yes Yes	Bidirectional
Burdwan does not granger cause Agra Agra does not granger cause Burdwan	6.06 6.27	0.0029 0.0024	Yes Yes	Bidirectional
Indore does not granger cause Agra Agra does not granger cause Indore	8.99 .15	0.0002 0.8591	Yes No	Unidirectional
Burdwan does not granger cause Ahmedabad Ahmedabad does not granger cause Burdwan	5.33 2.23	0.0057 0.1104	Yes No	Unidirectional
Indore does not granger cause Ahmedabad Ahmedabad does not granger cause Indore	18.29 0.50	7.E-08 0.6032	Yes No	Unidirectional
Indore does not granger cause Burdwan Burdwan does not granger cause Indore	15.81 0.30	5.E-07 0.7399	Yes No	Unidirectional

Vector Error Correction Model

The cointegration research showed the long-term movement in Indian potato markets, however, these particular market places may diverge in the near term. There is a chance of short-run disequilibrium after confirming the long-term equilibrium in the market pairs, which means that price changes in one market might not immediately affect the other market and might take some time. The VECM model is very sensitive to the incorporated number of lags appropriate number of lags was selected through using the lag selection criteria VAR model. The number of lags taken in VECM was two as the Akaike information criterion (AIC) was lowest at the order of two in the selected markets. The vector error technique is employed to calculate the rate at which markets adjust in order to long-term equilibrium and the same has been furnished in Table 9. The magnitude of ECT t-1 represents the error correction coefficients that estimate the response of repressors in each period of disequilibrium. In other, the error correction term estimates the speed of adjustment among the potato prices in the short run before their convergence to equilibrium in the long run. The coefficient of error correction term revealed that about 31 per cent adjustment towards the long-run equilibrium in the Agra market occurs in the period of one month.

$$\Delta \ln Agra_t = -0.31ECT_{t-1} - 0.31\Sigma\Delta \ln Agra_{t-1} - 0.26\Sigma\Delta \ln Agra_{t-2}$$

$$\Delta \ln Ahmedabadt = -0.13ECTt-1 - 0.32\ \Sigma\Delta \ln Agra\ t-2 - 0.40\ \Sigma\Delta \ln Ahmedabad\ t-1 + 0.23\ \Sigma\Delta \ln Burdwan\ t-1 + 0.67\ \Sigma\Delta \ln Indore\ t-1 + 0.44\ \Sigma\Delta \ln Indore\ t-2$$

$$\Delta \ln Burdwan_t = -0.18ECT_{t-1} + 0.23\Sigma\Delta \ln Agra_{t-1} + 0.46\Sigma\Delta \ln Indore_{t-1}$$

$$\Delta \ln Indore_t = -0.10ECT_{t-1} - 0.30\Sigma\Delta \ln Agra_{t-2} + 0.28\Sigma\Delta \ln Indore_{t-1}$$

Table 9: Results of error correction model in selected potato markets of India

Error correction	D(Agra)	D(Ahmedabad)	D(Burdwan)	D(Indore)
CointEq1	-0.311646 (0.08474) [-3.7788]	0.133291 (0.08836) [1.50843]	-0.182165 (0.08923) [-2.04163]	0.100902 (0.07684) [1.31317]
D (Agra (-1))	0.319459 (0.10454) [3.05589]	0.056092 (0.10902) [0.51453]	0.2313228 (0.11008) [2.10147]	0.002520 (0.09480) [0.02658]
D (agra (-2))	-0.262236 (0.10705) [-2.44969]	-0.328898 (0.11163) [-2.94624]	-0.055056 (0.11272) [-0.48842]	-0.301706 (0.09707) [-3.10805]
D (Ahmedabad (-1))	-0.021696 (0.10593) [-0.20481]	-0.401111 (0.11047) [-3.63103]	-0.116652 (0.11154) [-1.04579]	-0.088692 (0.09606) [-0.92331]
D (Ahmedabad (-2))	0.115967 (0.10468) [1.10783]	-0.162281 (0.10916) [-1.48660]	0.050829 (0.11023) [0.46113]	0.023543 (0.09492) [0.24802]
D (Burdwan (-1))	0.099029 (0.09563) [1.03554]	0.233745 (0.09973) [2.34387]	0.176592 (0.10070) [1.75368]	0.106677 (0.08672) [1.23015]
D (Burdwan (-2))	0.110984 (0.09232) [1.20218]	0.042624 (0.09627) [0.44274]	-0.260328 (0.09721) [-2.67796]	0.018465 (0.08372) [0.22057]
D(Indore (-1))	0.177386 (0.13057) [1.35852]	0.672656 (0.13617) [4.94000]	0.462899 (0.1374) [3.36671]	0.285006 (0.11840) [2.40705]
D(Indore (-2))	-0.108090 (0.13813) [-0.78255]	0.444038 (0.14404) [3.08273]	0.138961 (0.14544) [0.95542]	0.191908 (0.12525) [1.53217]
C	0.001954 (0.01384) [0.14121]	0.004343 (0.01443) [0.30098]	0.010932 (0.01457) [0.75032]	3.71E-05 (0.01255) 0.00295]

Note: Values in () and [ ] indicate Standard error and t-statistics

Conclusion

It is concluded that the price series of potato markets were found to stationarity at level itself as revealed by ADF and PP test. The findings of the Johansen cointegration test showed that potato markets are well integrated with each other. The findings of the Granger causality test revealed the existence of both a unidirectional and bidirectional price transmission relationship. Price signals are often frequently transmitted from one market to another as a result of greater market integration. Better infrastructure will generally lead to higher prosperity and benefits for India’s horticultural industry, which will help both producers and consumers. By better infrastructure facilities the reach of price transmission and market integration could be further enhanced.

Reference

1. AGMARKNET. Market database, Agricultural Marketing Information Network, 2021. Available from: http://agmarknet.gov.in. [Accessed 20 June 2021].
2. Basu JP. Cointegration and market integration: An application to the potato markets in Rural West Bengal, India, 2006. (No. 1004-2016-78839).
3. Devi IB, Srikala M, Ananda T, Subramanayam V, Venkatesu M. Spatial integration of cotton markets in India-An application of vector error correction model. Indian J Agric Marketing. 2015;29(2):147-154.
4. Dey S, Sinha K, Chand AK, Pandit P, Singh H, Sahu PK. Measuring price transmission, causality and impulse response: An empirical evidence from major potato markets in India. J Indian Soc Agric Stat. 2021;75(1):55-62.
5. Ghafoor A, Mustafa K, Abedullah. Cointegration and causality: An application to major mango markets in Pakistan. Lahore J Econ. 2009;14(1):85-113.
6. Johansen S, Juselius K. Maximum likelihood estimation and inference on cointegration with applications to the demand for money. Oxford Bull Econ Stat. 1990;52(2):169-210.
7. Katoch S, Singh R. Assessment of spatial price linkages in the major potato-assembling markets in India. Agric Econ Res Rev. 2020;33(1):75-84.
8. Kumar NR, Pandey NK, Rana RK. Price behavior of potatoes in Meerut wholesale market. J Indian Potato Assoc. 2018;30(2):203-204.
9. Mukim M, Singh K, Kanakaraj A. Market integration, transaction costs and the Indian wheat market: A systematic study. Econ Polit Wkly. 2009;44(22):149-155.
10. Rani R, Singh R, Tewari H, Singh SK, Singh PK. Integration of major Indian maize markets: A cointegration analysis. Int J Agric Stat Sci. 2017;13(2):601-606.
11. Reddy A. Market integration of grain legumes in India: The case of the chickpea market. SAARC J Agric. 2012;10(2):11-29.
12. Saha N, Kar A, Jha GK, Kumar P, Venkatesh P. A study of market integration of tomato in four major markets in India. Indian J Ext Educ. 2019;55(4):128-132.
13. Shami T, Adil S, Hassan S, Bashir M. Spatial market integration and price transmission in major potato markets of Punjab, Pakistan. Indian J Sci Technol. 2020;13(23):2328-2335.
14. Swaminathan B, Tarpara VD, Mistry HH. Spatial integration and price behavior analysis of major potato wholesale markets in Gujarat. Gujarat J Ext Educ. 2017;33:178-184.
15. Venujayakanth B, Dudhat AS, Swaminathan B, Ardeshana NJ. Price integration analysis of major groundnut domestic markets in India. Econ Affairs. 2017;62(2):233-241.