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Spatial integration and price transmission among major potato markets in India

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ABSTRACT

The present study examined the spatial market integration across four major potato markets, viz. Agra, Bengaluru, Delhi and Mumbai for the period January, 2005–March, 2018. Johansen's multivariate co-integration approach has been applied to identify the possible market integration. The results of Johansen's co-integration test for different markets revealed that all the six market pairs are co-integrated, demonstrating that the selected potato markets have long-run price linkage across them. To supplement the finding of Johansen's co-integration analysis, we assessed the nature and extent of long run and short run causal relationship between the markets. The results of long run causality showed bidirectional causality for the market pairs: Agra ↔ Bengaluru, Agra ↔ Mumbai, Bengaluru ↔ Delhi and Bengaluru ↔ Mumbai, whereas for market pairs Agra→ Delhi and Mumbai→ Delhi have long-run unidirectional causality. To get the additional evidence as to whether and in which direction price transmission is occurring between the market pairs in short run, Wald test has been used.

Key words: Co-integration analysis, Causality, Market integration, Potato

Potato (*Solanum tuberosum* L.) is one of the most important food crops after wheat, maize and rice, contributing to food and nutritional security of the world. At present India is the second largest producer of potato in the world after China. Potato popularly known as 'king of vegetables' is the most important vegetable of the country contributing to the extent of 21% in terms of area under vegetable cultivation and 25.5% of total production of vegetable (Indian horticulture Database, 2017). In India, potato production has grown strongly over the past 25 years to a record 46.54 million tons in 2016-17, compared to the 18.19 million tons of 1991-92 (Horticultural Statistics at a Glance 2017). Among agricultural commodities, vegetable prices are more unstable due to perishable nature, seasonality of production, production uncertainty, etc (Choudhary *et al.* 2019a). Due to volatile nature of its price, marketing of potato is a major concern for farmers. Lack of information on potential market as well as arrival and price behaviour of potato further worsen this situation for potato growers.

Market integration is the study of price differences between spatially separated markets and is an important economic analytical tool used to understand markets better. The correct price signal will not be transmitted through the marketing channels if the markets are not integrated (Fackler and Tastan 2008). Inaccurate price signals might distort the marketing decisions of farmers and cause inefficient product movement.

Policies implemented in the potato industry would be more costly and could be ineffective with the lack of market integration. Given the importance of the potato as a product and the significance of the industry it is of great importance for the markets, as price setting mechanism, to function properly. Otherwise, farmers may not receive fair prices for their produce and consumers will pay more. Keeping this in view, current study was attempted to examine the price behavior and spatial integration among major potato markets in India.

MATERIALS AND METHODS

The study is completely based on secondary data. The data used in the empirical analysis comprises monthly wholesale prices (₹/q) of potato of Agra, Bengaluru, Delhi and Mumbai markets for the period January, 2005–March, 2018. Identification of important markets has been done on the basis of arrival data of last five years as well as availability of the data. The wholesale price of potato was obtained from National Horticultural Research and Development Foundation (NHRDF) (http://nhrdf.org/en-us/).

Often economic variables are non-stationary. If price data are non-stationary, long run relationships between price variables estimated using ordinary least square regression techniques could be invalid. Therefore, before further analysis on the data, a test on the data generating process

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of the price series needs to be conducted. In other words, the presence of a unit root in the price series need to be checked and appropriate action taken to convert the series to a stationary process. In this study, the presence of unit root is done using Augmented Dickey-Fuller (ADF) test and Philips-Perron (PP) test.

In order to determine whether co-integration relationships exist between the variables, lag length (k) and co-integration rank (r) must be determined. Johansen (1990) proposed a two-step method to first determine the lag length using either an information criterion or a likelihood ratio test and then to determine the co-integrating rank using likelihood ratio test, such as the λ max test or the trace test. The Johansen co-integration procedure is based upon an unrestricted vector autoregressive (VAR) model specified in error-correction form as follows:

$$Y_t = A_1 Y_{t-1} + A_2 Y_{t-2} + ...+ A_k Y_{t-k} + e_t$$

$$\Delta Y_t = \prod Y_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta Y_{t-i} + e_t \quad (1)$$

where $\prod = (I - A_1 - A_2 - ... - A_k)$ and $\Gamma_i = (I - A_1 - A_2 - .... - A_i)$, $i = 1, ..., k - 1$

Y_t include all p variables of the model which are $\sim I(1)$, Π and Γ_i are parameter matrices to be estimated, e_t is a vector of random errors which follow a normal distribution with zero mean and constant variance. The Johansen co-integration method estimates the Π matrix through an unrestricted VAR and tests whether one can reject the restriction implied by the reduced rank of Π.

The existence of co-integration in the bi-variate relationship implies Granger causality at least in one direction, which can be tested within the framework of Johansen's co-integration under certain restrictions by the Wald test. In the co-integration matrix Π, if the θ matrix has a complete column of zeros, no causal relationship exists since, there is no co-integrating vector appears in that particular block. Pair wise causal relationship of the variable can be represented as follows:

$$\begin{bmatrix} \Delta Y_{1,t} \\ \Delta Y_{2,t} \end{bmatrix} = \begin{bmatrix} \mu_1 \\ \mu_2 \end{bmatrix} + \begin{bmatrix} \alpha_1 \\ \alpha_2 \end{bmatrix} \left(Y_{1,t-1} - \beta Y_{2,t-1} \right) + A_1 \begin{bmatrix} \Delta Y_{1,t-1} \\ \Delta Y_{2,t-k} \end{bmatrix} + \begin{bmatrix} e_{1t} \\ e_{2t} \end{bmatrix} \quad (2)$$

Parameters contained in matrices A_k measure the short-run causality relationship, while β is the co-integrating parameter that explains the long-run equilibrium relationship between the series. From Eq. (2), three possibilities for long-run causality may be identified, (i) $\alpha_1 \neq 0$, $\alpha_2 \neq 0$; (ii) $\alpha_1 = 0$, $\alpha_2 \neq 0$; and (iii) $\alpha_1 \neq 0$, $\alpha_2 = 0$ (Kumar and Jha 2017). In the above three cases, the first case indicates bi-directional causality, while the second and third imply uni-directional causality. Wald test with the null hypothesis that the joint contribution of the lags of endogenous variables is equal to zero has been applied to analyze for short-run causality. If the null hypothesis cannot be rejected it implies that the respective endogenous variables can be treated as exogenous in the system.

RESULTS AND DISCUSSION

The time plot of all the series (Fig 1) clearly indicate the non-stationarity behaviour of the typical agricultural price data.

The mean price of potato for the period of January, 2005 to March, 2018 for the major four markets across India was the lowest at ₹ 643.43 per quintal in Agra market. It may be due to Agra is a production market and remaining three are consumption markets. The highest average price was recorded at ₹ 1111.43 per quintal in Bengaluru market. The minimum price was recorded in Agra market, at price of ₹ 147 per quintal, whereas the maximum price was recorded in Bengaluru market, at price of ₹ 2480 per quintal. Coefficient

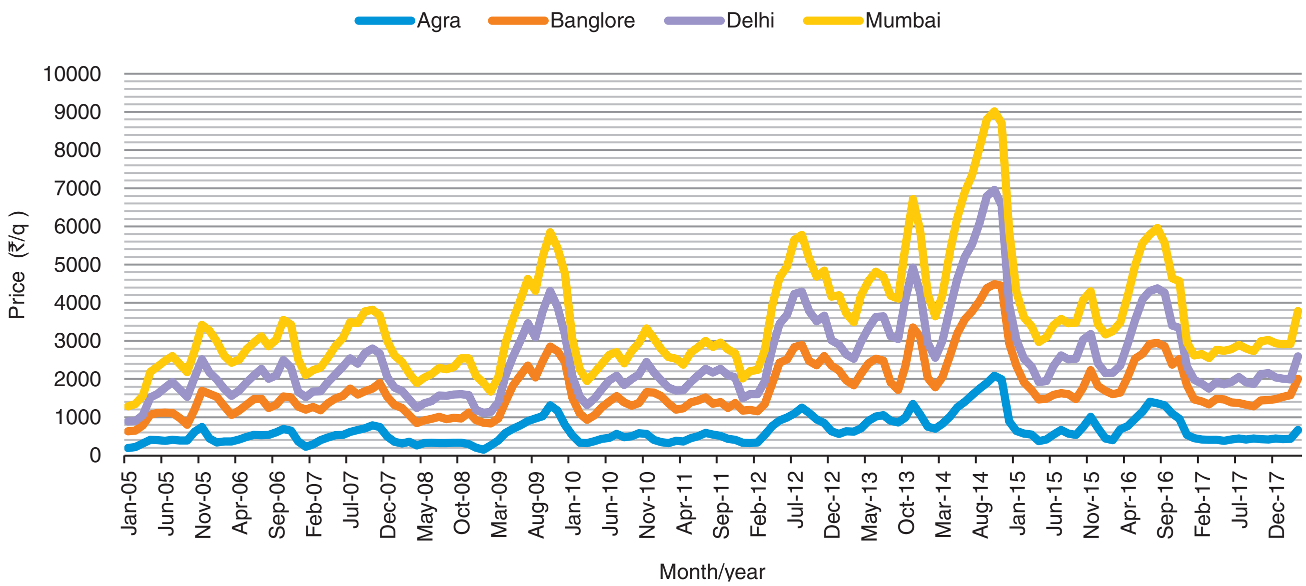

Fig 1 Time plot of monthly potato wholesale prices of major markets (*Source:* National Horticultural Research and Development Foundation).

of variation (cv), a crude measure of volatility, indicates that Mumbai market has the lowest price volatility which is represented by 34.56% compared to 56.13% in Agra market, which has the highest price volatility. The price series of all markets appear to follow non-normal distribution and are leptokurtic in nature. Large fluctuations in the prices of a commodity may result in switching over of farmers to some other crops. The stable price level of potato will provide incentives to the farmers to increase the production and adapt to new technology which stabilize the farm income.

While investigating market integration, the first step is to check for the evidence of non-stationarity of data in order to confirm that co-integration approach is the appropriate method. In this study to check the non-stationarity of the price series, we used ADF test and PP test. At level, we have found that all the major potato price series were non-stationary according to the Augmented Dickey Fuller (ADF) and Philips-Perron (PP) test results. It indicates that series has time dependent statistical properties which may be stochastic or deterministic. Augmented Dickey Fuller and Philips-Perron test showed that the price series become stationary when first difference is done. It indicates that the price series were suitable for co-integration analysis.

To check for co-integration among different potato markets, a test for a suitable lag length to be included in the co-integration analysis was performed. Results of co-integration tests are quite sensitive to lag length included in the model. The number of lags is selected by applying Schwarz's information criterion (SIC). A Vector Auto-regression (VAR) on the differenced series was conducted and lags length of the model with the least SIC values chosen as the appropriate lag length for the co-integration test. For Agra and Bengaluru markets, the pre estimation lag selection criteria indicates the average maximum lag length for the model to be used in the analysis was 2 lag i.e. 2 month. It indicates the maximum time for price to be transmitted from one potato market (Agra) to the other (Bengaluru) in the long run or to move into long run equilibrium is about two (2) month at most.

In order to identify a possible co-integration among selected major potato markets, each market was paired with each other, resulting into 6 bi-variate systems, viz. Agra – Bengaluru, Agra – Delhi, Agra – Mumbai, Bengaluru – Delhi, Bengaluru – Mumbai and Delhi – Mumbai. Since the data series are integrated of the same order, co-integration techniques can be used to determine whether a stable long-run relationship exists between each pair. The Johansen's method of co-integration was applied to check for co-integration among selected major potato markets. The results of Johansen's co-integration test for different markets are presented in Table 1 using the trace statistic and maximum Eigen value statistic. The trace statistic and maximum Eigen value statistic has resulted the same conclusion that all the six market pairs are co-integrated. In other words we can say that all the four selected potato markets are well integrated and price signals are transferred from one market to the other to ensure efficiency. Thus,

Table 1 Bi-variate Johansen's co-integration rank test results

	λ_{trace}statistic	Prob.	λ_{max}Statistic	Prob.
Agra – Bengaluru				
$H_0 : r = 0 vs H_1 : r \geq 1$	30.57	<0.001	30.14	<0.001
$H_0 : r \leq 1 vs H_1 : r \geq 2$	0.42	0.576	0.42	0.576
Agra – Delhi				
$H_0 : r = 0 vs H_i : r \geq 1$	27.54	<0.001	24.90	<0.001
$H_0 : r \leq 1 vs H_1 : r \geq 2$	2.64	0.122	2.64	0.122
Agra – Mumbai				
$H_0 : r = 0 vs H_1 : r \geq 1$	22.17	<0.001	21.93	<0.001
$H_0 : r \leq 1 vs H_1 : r \geq 2$	0.24	0.682	0.24	0.682
Bengaluru – Delhi				
$H_0 : r = 0 vs H_1 : r \geq 1$	42.53	<0.001	42.04	<0.001
$H_0 : r \leq 1 vs H_1 : r \geq 2$	0.49	0.547	0.49	0.547
Bengaluru – Mumbai				
$H_0 : r = 0 vs H_1 : r \geq 1$	27.91	<0.001	27.48	<0.001
$H_0 : r \leq 1 vs H_1 : r \geq 2$	0.43	0.572	0.43	0.571
Delhi – Mumbai				
$H_0 : r = 0 vs H_1 : r \geq 1$	33.57	<0.001	33.33	<0.001
$H_0 : r \leq 1 vs H_1 : r \geq 2$	0.24	0.682	0.24	0.682

Johnson's co-integration test has shown that even though the selected potato markets in India are geographically isolated and spatially segmented, they are well-connected in terms of prices of potato, demonstrating that the selected potato markets have long-run price linkage across them. This means that, selected major potato market prices in India move closely together in the long run although in the short run they may drift apart. This also indicates that the potato marketing is an open market of which the forces of demand and supply are the determinant of the various market prices hence ensuring high efficiencies between spatial markets.

In this study we found long-run bidirectional causality for the market pairs: Agra ↔ Bengaluru, Agra ↔ Mumbai, Bengaluru ↔ Delhi and Bengaluru ↔ Mumbai, whereas for market pairs Agra→ Delhi and Mumbai→ Delhi have long-run unidirectional causality (Table 2). To check short run causality, we applied Wald test. According to the Wald test, there were short run unidirectional causalities between the market pairs: Bengaluru → Agra, Agra → Mumbai, Mumbai → Bengaluru and Delhi → Mumbai markets, meaning that a price change in the former market in each pair causes the price formation in the latter market in short run, whereas the price change in the latter market is not feedbacked by the price change in the former market in each pair. There were short run bidirectional causalities for the market pairs: Agra ↔Delhi and Bengaluru↔ Delhi.

In order to provide insight on the dynamics of different potato markets, the concept of co-integration and the extent of price causality were analysed using monthly potato prices of Agra, Bengaluru, Delhi and Mumbai markets during January, 2005 – March, 2018. In this study, we utilized Johansen's test of co-integration to check integration of

Table 2 Estimate of error correction term from ECM for different agricultural market

Model	Estimate of error correction term from ECM (Long run causality)				Short run causality by Wald Test	
	Regressors	Parameter estimated	t- test	P value	Chi-square test	P value
Bengaluru → Agra	ECT_{t-1}	-0.27	-3.33	<0.001	6.21	0.044
Agra→Bengaluru	ECT_{t-1}	-0.26	-3.42	<0.001	4.76	0.092
Delhi→ Agra	ECT_{t-1}	0.09	1.01	0.308	59.08	<0.001
Agra→Delhi	ECT_{t-1}	-0.62	-5.15	<0.001	10.20	0.006
Mumbai→ Agra	ECT_{t-1}	-0.29	-3.19	0.001	1.86	0.394
Agra→Mumbai	ECT_{t-1}	-0.15	-2.02	<0.001	22.22	<0.001
Delhi→ Bengaluru	ECT_{t-1}	-0.15	-2.80	0.005	5.59	0.061
Bengaluru→Delhi	ECT_{t-1}	-0.32	-4.87	<0.001	13.27	0.001
Mumbai→ Bengaluru	ECT_{t-1}	-0.24	-2.51	0.012	6.79	0.033
Bengaluru→Mumbai	ECT_{t-1}	-0.19	-2.03	0.043	2.72	0.255
Mumbai→ Delhi	ECT_{t-1}	-0.38	-5.11	<0.001	4.24	0.115
Delhi→Mumbai	ECT_{t-1}	-0.04	-0.87	0.382	30.00	<0.001

Note: A → B = A causes B

potato markets. The results of overall co-integration test have indicated that different potato markets in India are well-integrated and have long-run price association across them, which revealed that the potato markets have high efficiency. The results of present investigation suggest the need of market surveillance and real time price forecasting of potato so that the timely action can be taken to regulate trade environment as well as price advisories can be issued to producers considering the domestic and global production environment.

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