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# Integration of prices in major markets of onion and potato in India

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ABSTRACT

Among the vegetable crops, onion and potato prices are more unstable due to seasonality of production, perishable nature, production uncertainty etc. Lack of information on potential market as well as arrival and price behaviour of onion and potato further worsen this situation of its growers. Since market integration helps in achieving price consistency and thus lead to marketing system efficiency, the present study explores market integration and price transmission during the period March 2009 to March 2019 across the wholesale markets using Johansen's cointegration test and Granger Causality test. In this study to test the stationarity of the price series, Augmented Dickey Fuller test and Phillips-Perron test was used. The outcomes of the study strongly supported the presence of co-integration and interdependence of the selected markets from the result of Johansen cointegration test and Granger causality test revealed the presence of bidirectional relationship among most of the markets but also there exists unidirectional relationship among few markets.

**Keywords**: Causality, Cointegration, Market integration, Price transmission

Potato and Onion are the two most important and highest produced vegetables in India. But with such high production also, often their prices remain volatile in the domestic market due to seasonal production, inelastic nature of demand. Supply shock due to excess rainfall or drought cause large fluctuations in market arrivals which quickly affect the price. Along with that, prices are also affected by other variables like varieties, appearance, moisture content, colour etc. (Reddy *et al.* 2012).Unanticipated and substantial price fluctuations can lead to low production and instability in farm income as they discourage farmers from adopting improved production methods (Anuja *et al.* 2013). In addition to generating income uncertainty, price fluctuations often result in unpredictable agricultural investment and pose major challenges for policymakers to develop effective pricing and marketing policies that are articulated to minimize risk (Saha *et al*. 2019).

Market integration is an indicator of efficient marketing system as it shows the extent to which prices in different markets move together. Market integration and price forecasting helps to stabilise prices and direct the selection of the most effective market, by removing imperfections and achieving market competence (Wani *et al.* 2015). It has also been found that those commodities on which interstate or inter-regional restrictions have not been imposed are well integrated in their markets compared to those with such restrictions (Sekhar 2012). Market integration also plays a vital role in determining pattern and pace of diversification towards the high value crops (Sidhu *et al*. 2010). The non-integrated markets provide an inaccurate picture of price information, which can distort producers' production decisions and contribute to inefficiencies in agricultural markets, harm ultimate consumers and lead to low production and slow growth (Mukhtar and Javed 2008). For efficient functioning of markets, so that producers get remunerative prices and to allow the customers to get a variety of products at a fair price. With this background, this paper aims to analyze the present situation of markets integration among the major markets of onion and potato along with the price transmission within the markets.

## MATERIALS AND METHODS

The present study used weekly wholesale prices (₹ per q) of onion and potato in four major markets for the period of March 2009 to March 2019. All the relevant data were collected from www.agmarknet.gov.in. Daily price data were collected at first and weekly prices were calculated. Markets are selected on the basis of market arrival and data availability. For potato Agra, Azadpur, Bengaluru and Burdwan markets and for onion Ahmedabad, Lasalgaon, Azadpur and Bengaluru markets were identified as major markets.

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Regression analysis of non-stationary time series can lead to spurious results which can be misleading (Ghafoor *et al*. 2009). Cointegration is the most appropriate method for working with non-stationary time series to estimate long-run equilibrium relationships. It necessitates that time series should be integrated of the same order. Before performing the cointegration test, the data must be verified for the presence of unit root. Augmented Dickey Fuller (ADF) test and Phillips-Perron (PP) test was used for this purpose. The null hypothesis is that the price series has unit root present in it which indicates non-stationarity.

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} \sum_{i=1}^{m} \alpha_i \Delta Y_{t-i} + \varepsilon_t$$

where, $Y_t$ = Price of sample vegetable in a given market at time $t$, $\Delta Y_t = Y_t - Y_{t-1}$, ε = Pure white noise error term, m = Optimal lag value which is selected on the basis of Schwartz Information Criterion (SIC) and Akaike Information Criterion (AIC).

Phillips-Perron test is a non-parametric test which was also used. It is used mainly to confirm the result of ADF test is valid or not. It is built on the same null hypothesis like the Augmented Dickey Fuller Test.

*Market integration refers to a long-term relationship between prices across regions*: Once all the price series confirm the presence of stationarity at same order of differences, the cointegration of markets can be tested. Johansen's cointegration test is used to test the cointegration between the markets. If two variables are having long term, equilibrium relationship between them, then they are said to be integrated.

$$\Delta Y_t = \sum \Pi_i \Delta Y_{t-i} + \Pi Y_{t-k} + \varepsilon_t$$

where, $Y_t$= vector of price time series, $\Delta Y_t$ = first order difference and matrix, $\prod = \alpha\beta^1$ is $n \times n$ order with rank '$r$' ($0 \leq r \leq n$), the no. of independent cointegration relations, α is the speed of adjustment to the disequilibrium, $\beta$ is the long-term coefficients. The model was estimated by regressing $\Delta Y_t$ matrix against the lagged differences ('$k$' lags) of $\Delta Y_t$ to determine the no. of cointegration vectors, the rank of $\prod = \alpha\beta^1$ has to be found.

The Johansen cointegration test explained that if the cointegration exists among the variables, then Granger causality must also exist either unidirectional or bidirectional. So, the test was used to disclose whether there is any causal relationship between the price series. The causality direction of long-run market price relationship can be assessed by using the Granger causality test directed within vector auto regressive (VAR) model. An autoregressive distributed lag (ADL) model for the Granger- causality test had been specified as below:

$$X_t = \sum_{i=1}^{n} \alpha_i Y_{t-i} + \sum_{j=1}^{n} \beta_j X_{t-j} + \mu_{10}$$

$$Y_t = \sum_{i=1}^{n} \lambda_i Y_{t-i} + \sum_{j=1}^{n} \delta_j X_{t-j} + \mu_{20}$$

where $\mu_{10}$ and $\mu_{20}$ are error terms, t = time period, $X_t$ and $Y_t$ are the price series of two different markets. To test the pattern of causality between two markets, F test was used. The null hypothesis $H_0$: The lagged $X_t$ does not granger cause $Y_t$ and the Alternative hypothesis $H_1$: The lagged $X_t$ granger cause $Y_t$. Here F statistic must be used in combination with the p value when deciding about the significance of the results. If p value is less than the alpha level, individual p values are studied to find out which of the individual variables are statistically significant.

## RESULTS AND DISCUSSION

Several factors lead to price fluctuations, some of which are all year-round demand for these crops, very short shelf life, difference in seasonal output level, weather conditions, market imperfections such as flawed auction practices, hoarding of traders, speculative activities, etc. But price instability and distorted price movements fail to direct farmers and build resource allocation imbalances (Saha *et al*. 2019). Market integration is indicator of the existence of efficient functioning of markets. So, analysis of market is particularly important as presence of integration influences the conduct of the firms of the markets and marketing efficiency, and also when markets are well integrated govt. need to make very little effort to impact the price process in those markets (Awal *et al.* 2007). But for performing cointegration test, ADF and PP test should be done to check the stationarity of the data series.

*Unit root test*: Graphical presentation of price series data at level of all the four markets of onion and potato are presented in the Fig 1 and 2 respectively. Time plot of price series at level of the markets showed that during some period there is an increasing trend of price and at other times it is decreasing. It indicates that the prices are continuously fluctuating and their mean and variance are not constant over the time. Non-constancy of mean and variance of a series indicates nothing but non-stationarity of the data series.

It was detected as non-stationary by the visual inspection of the data but traditional statistical approach such as Augmented Dickey-Fuller (ADF) test is used for further study. To confirm the result of ADF test, another non-parametric test namely Phillips-Perron (PP) test is also used.

ADF statistic of all the onion markets revealed that the null hypothesis of the presence of unit root was not rejected at 5% level (Table 1). However, it became stationary after taking 1st difference. Similar result observed for the potato markets. PP test results confirm the result of ADF test. Non stationarity of the data series at their level indicates that means and variances of that series is changing over the period of time which is quite natural specially for onion and potato price which exerts high variability from time to time.

*Market integration (Johansen's cointegration test)*: In the next step, cointegration between the stationary price series has been tested by using Johansen's Trace and Maximum Eigen-value tests. To proceed with the cointegration analysis, it was necessary to confirm that all the series are integrated

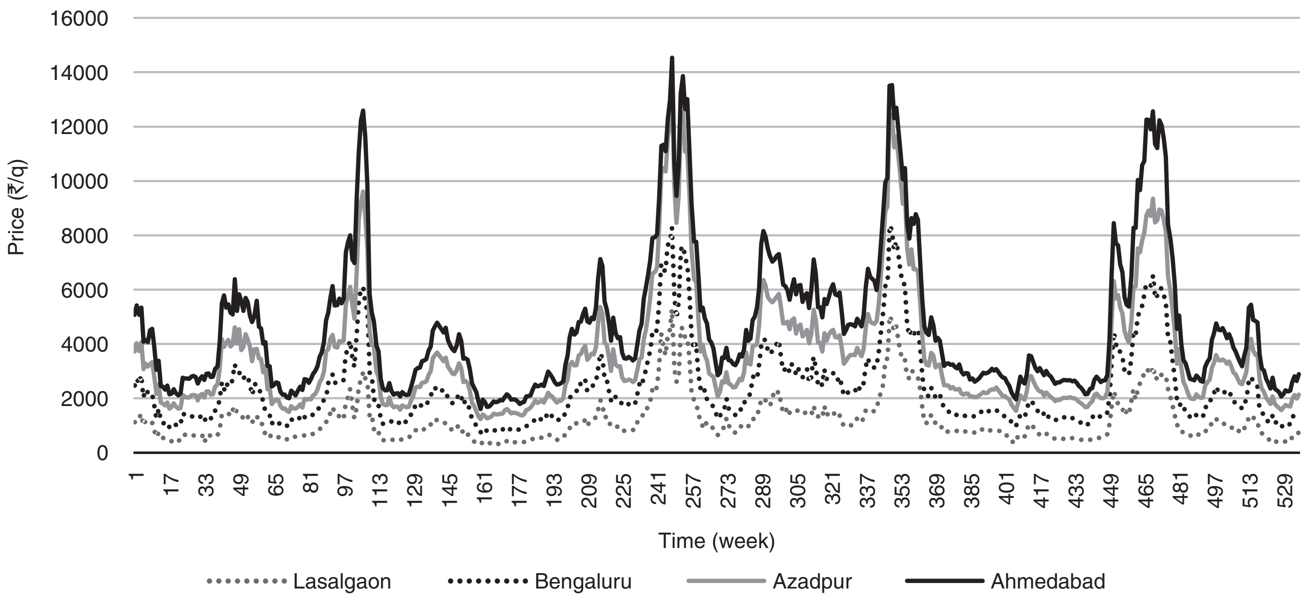


Fig 1 Time plot of onion price data (at level) of all markets (March 2009-March 2019).

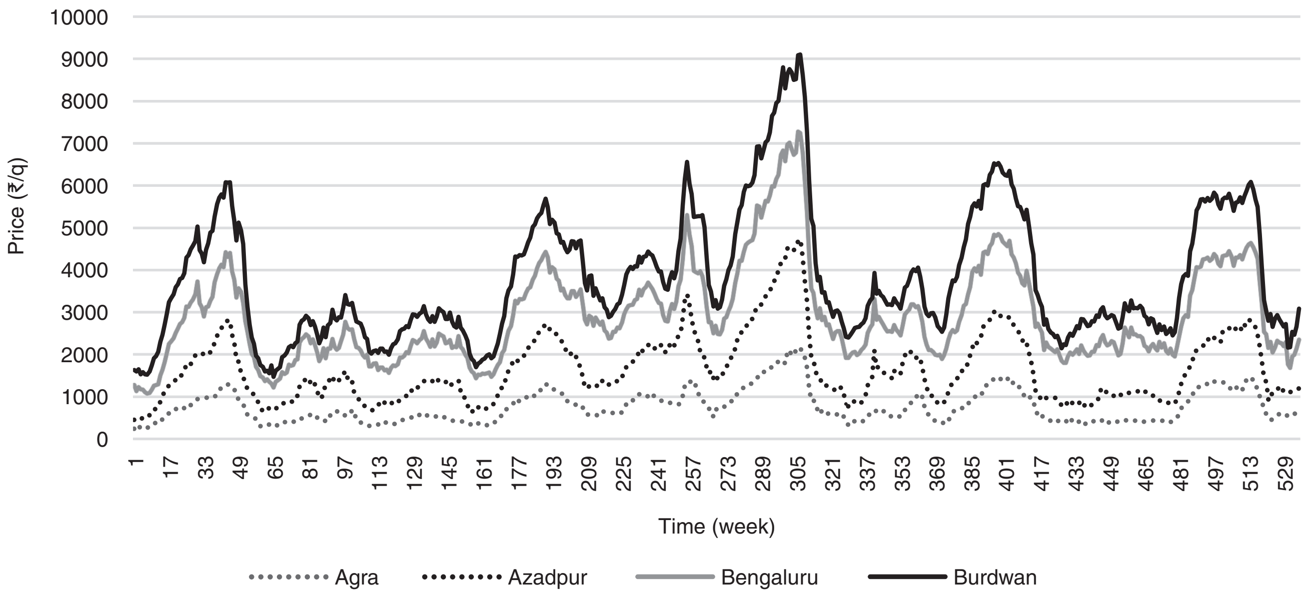


Fig 2 Time plot of potato price data (at level) of all markets (March 2009-March 2019).

of the same order. Since it was found that the data of all the markets of both the crops are integrated of order 1, i.e. I(1), it fulfilled the criteria of performing Johansen cointegration test. Two types of statistics are presented (Table 2), one is trace statistic and another one is maximum eigenvalue statistic. The cointegration analysis showed that test rejects the null hypothesis of no cointegration relationship and clearly indicates that there exists one cointegration equation in each pair of the markets. As all the markets are found co-integrated among themselves, it implies that there exists long run equilibrium price relationship and price moves together in these markets which may be due to presence of well-built market intelligence and market information system.

*Price transmission (Granger Causality Test)*: After confirming the integration of prices series, in the next step, pair-wise Granger causality test is performed for the markets to comprehend causal relation between them. The granger causality shows the direction of price formation between two markets and related spatial arbitrage, i.e. physical movement of the commodity to adjust the prices difference (Ghafoor *et al*. 2009).

The presence of bidirectional causal relationship means both the markets transmits price information to the other one however unidirectional price transmission indicates that price of only one market transmits to other one but not the other one.

Data (Table 3) revealed that Lasalgaon, Ahmedabad and Bengaluru all are price determining markets. These three markets have expressed bidirectional relationship with all the other markets, but the scenario is little different with

Table 1 Estimated ADF and PP statistic for unit root test

| Market | | ADF test | | Phillips-Perron test | |
|---|---|---|---|---|---|
| | | t statistic | Prob. | t statistic | Prob. |
| *Onion* | | | | | |
| Lasalgaon | Level | -1.91 | 0.053 | -1.89 | 0.055 |
| | 1st Difference | -18.46*** | <0.001 | -18.55*** | <0.001 |
| Bengaluru | Level | -1.79 | 0.069 | -1.86 | 0.059 |
| | 1st Difference | -19.40*** | <0.001 | -19.40*** | <0.001 |
| Azadpur | Level | -1.93 | 0.051 | -1.93 | 0.051 |
| | 1st Difference | -10.95*** | <0.001 | -25.23*** | <0.001 |
| Ahmedabad | Level | -1.80 | 0.068 | -1.86 | 0.59 |
| | 1st Difference | -21.17*** | <0.001 | -21.23*** | <0.001 |
| *Potato* | | | | | |
| Agra | Level | -1.63 | 0.09 | -1.47 | 0.13 |
| | 1st Difference | -10.02*** | <0.001 | -16.83*** | <0.001 |
| Azadpur | Level | -1.55 | 0.11 | -1.52 | 0.12 |
| | 1st Difference | -11.78*** | <0.001 | -19.39*** | <0.001 |
| Bengaluru | Level | -0.92 | 0.31 | -0.94 | 0.29 |
| | 1st Difference | -23.98*** | <0.001 | -23.96*** | <0.001 |
| Burdwan | Level | -1.31 | 0.17 | -1.41 | 0.14 |
| | 1st Difference | -12.20*** | <0.001 | -18.78*** | <0.001 |

***indicates significance at 1% of MacKinnon (1996) one-sided p-values.

Table 2 Estimates of Johansen Cointegration test

| Markets | Hypothesized no. of CE(s) | Trace statistic | Prob. | Max. eigen statistic | Prob. |
|---|---|---|---|---|---|
| *Onion* | | | | | |
| Ahmedabad-Azadpur | None ** | 22.69** | <0.001 | 19.72** | <0.001 |
| | At most 1 | 2.96 | 0.10 | 2.96 | 0.10 |
| Ahmedabad-Bengaluru | None ** | 27.03** | <0.001 | 23.88** | <0.001 |
| | At most 1 | 3.14 | 0.09 | 3.14 | 0.09 |
| Ahmedabad-Lasalgaon | None ** | 24.00** | <0.001 | 21.02** | <0.001 |
| | At most 1 | 2.98 | 0.09 | 2.98 | 0.09 |
| Azadpur-Bengaluru | None ** | 51.79** | <0.001 | 47.27** | <0.001 |
| | At most 1 | 4.51 | 0.03 | 4.51 | 0.03 |
| Azadpur-Lasalgaon | None ** | 54.89** | <0.001 | 51.20** | <0.001 |
| | At most 1 | 3.68 | 0.06 | 3.68 | 0.06 |
| Bengaluru-Lasalgaon | None ** | 55.72** | <0.001 | 51.99** | <0.001 |
| | At most 1 | 3.72 | 0.06 | 3.72 | 0.06 |
| *Potato* | | | | | |
| Agra-Azadpur | None ** | 31.45** | <0.001 | 28.54** | <0.001 |
| | At most 1 | 2.90 | 0.10 | 2.90 | 0.10 |
| Agra-Bengaluru | None ** | 25.63** | <0.001 | 24.59** | <0.001 |
| | At most 1 | 1.03 | 0.35 | 2.03 | 0.35 |
| Agra-Burdwan | None ** | 30.02** | <0.001 | 27.32** | <0.001 |
| | At most 1 | 2.69 | 0.11 | 2.69 | 0.11 |
| Azadpur-Bengaluru | None ** | 30.06** | <0.001 | 29.22** | <0.001 |
| | At most 1 | 0.84 | 0.41 | 0.84 | 0.41 |
| Azadpur-Burdwan | None ** | 26.12** | <0.001 | 23.78** | <0.001 |
| | At most 1 | 0.33 | 0.14 | 2.32 | 0.14 |
| Bengaluru-Burdwan | None ** | 23.09** | <0.001 | 22.09** | <0.001 |
| | At most 1 | 1.004 | 0.36 | 1.004 | 0.36 |

**denotes rejection of the hypothesis at the 5% level.

Table 3 Results of Granger Causality test

| | F statistic | Prob. | Granger cause | Direction |
|---|---|---|---|---|
| *Onion price series* | | | | |
| Azadpur → Ahmedabad | 2.87 | 0.056 | No | Unidirectional |
| Ahmedabad → Azadpur | 6.68 | 0.001 | Yes | |
| Bengaluru → Ahmedabad | 10.01 | <0.001 | Yes | Bidirectional |
| Ahmedabad → Bengaluru | 5.03 | 0.006 | Yes | |
| Lasalgaon → Ahmedabad | 8.14 | <0.001 | Yes | Bidirectional |
| Ahmedabad → Lasalgaon | 4.62 | 0.010 | Yes | |
| Bengaluru → Azadpur | 56.00 | <0.001 | Yes | Unidirectional |
| Azadpur → Bengaluru | 2.17 | 0.11 | No | |
| Lasalgaon → Azadpur | 54.91 | <0.001 | Yes | Bidirectional |
| Azadpur → Lasalgaon | 4.95 | 0.007 | Yes | |
| Lasalgaon → Bengaluru | 5.88 | 0.003 | Yes | Bidirectional |
| Bengaluru → Lasalgaon | 23.05 | <0.001 | Yes | |
| *Potato price series* | | | | |
| Agra → Azadpur | 14.96 | <0.001 | Yes | Bidirectional |
| Azadpur → Agra | 50.82 | <0.001 | Yes | |
| Agra → Bengaluru | 17.47 | <0.001 | Yes | Bidirectional |
| Bengaluru → Agra | 4.248 | 0.014 | Yes | |
| Agra → Burdwan | 15.19 | <0.001 | Yes | Bidirectional |
| Burdwan → Agra | 8.71 | 0<.001 | Yes | |
| Bengaluru → Azadpur | 1.50 | 0.22 | No | Unidirectional |
| Azadpur → Bengaluru | 15.82 | <0.001 | Yes | |
| Burdwan → Azadpur | 6.72 | 0.001 | Yes | Bidirectional |
| Azadpur → Burdwan | 12.30 | <0.001 | Yes | |
| Burdwan → Bengaluru | 19.75 | <0.001 | Yes | Unidirectional |
| Bengaluru → Burdwan | 2.71 | 0.067 | No | |

Azadpur market. Azadpur market expressed bidirectional causal relationship only with Lasalgaon market, but it failed to express any such causal relationship with Ahmedabad market which could be due to the fact that Azadpur is solely a consumption market, so it does not influence the prices of Ahmedabad market which is particularly a production market, and also it does not influence the prices of Bengaluru market which may be due to the vast geographical distance between the two. From Table 3 we also found that except Bengaluru market, other three market, i.e. Azadpur, Agra and Burdwan market expressed bidirectional causality relationship with all of the other three markets. Bengaluru market have price transmission relationship with only Agra market but there is no causality relationship with Azadpur market which can be attributed to the long distance between the two markets and also with Burdwan market which may be due to geographical distance as well as the fact that potato production is very high in West Bengal and potato is transported from Burdwan to Bengaluru market which is majorly consumption market.

It is concluded that price in all the markets of onion as well as potato as revealed by ADF and PP test were non-stationary at level and stationary at $1^{st}$ difference, and all the markets of onion, potato were detected to be well integrated with each other by cointegration test. Granger Causality test results established the presence of bidirectional as well as unidirectional price transmission relationship. Presence of bidirectional price transmission relationship among most of the market combinations indicate that the information about price changes in one market to another market was transmitted to a great extent, which could be due to quick absorption of price signals, logistical advantage, good communication facilities and transport services.

Improving the degree of market integration often leads to the transfer of price signals from one market to another market. In general, if better infrastructural facilities are provided, the horticultural sector of India will prosper and achieve greater benefits for both the consumer and the producer (Vasisht *et al.* 2008). It is recommended that by concentrating on road development, improvement of existing roads, better communication facilities and other market-related infrastructures, the reach of market integration and price transmission could be further enhanced.

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