# Market Integration and Price Transmission Analysis of Onion in Wholesale Markets of India


## Abstract

The present study was done in seven major onion wholesale markets in India, namely Pimpalgaon, Lasalgaon, Solapur, Pune, Bangalore, Hyderabad and Indore to explore the interdependence of wholesale prices amongst Indian onion markets. The study was conducted in all India perspective and the study period involves the seventeen years data of onion wholesale prices (January 2004 to December 2020). The study was majorly based on the prices of onion obtained through secondary source. These data were collected from various portals such as FAO, NHRDF, Agmarknet and NHB. The current study employs co-integration analysis of wholesale monthly onion prices in selected marketplaces to determine the degree of market integration. The Trace and Maximum Eigen-value tests results showed that the onion prices in India moves together in the long run equilibrium. As a result, it may be stated that India's onion markets are well-functioning. The direction of information flow was determined by using Granger Causality test. It was found that in few markets pairs, price transmissions were bi-directional whereas between Bangalore and Pune market, no transmission was found. The study reveals that Lasalgaon market is dominating in terms of price determination. The empirical study also recommends keeping a careful eye on diverse market behavioural patterns, since "news" in one market might have an influence on other markets due to the numerous interdependencies.



**Keywords:** Granger Causality, Price transmissions, Stationary test, bi-directional.




## Introduction

“Onion is considered as the most highly volatile crop among the vegetables, showing increasing fluctuation of unexpected price spikes & falls. In India, the marketing of onions is characterized by low market intelligence as well as uncertainty about future prices, which has been a major issue for producers & consumers. In recent years, such extreme price movements have attracted the attention of policy makers. Prices in horticultural crops play an important role in distributing the resources efficiently and signalling shortages and surpluses, which help the farmers to respond to dynamic market conditions” (Haji and Gelaw, 2011). “Onion production in India is concentrated primarily in Maharashtra, which accounts for around 30% of total onion output” (GOI, 2016). “As a result, supply shocks in major onion-producing regions triggered by either excessive rainfall or drought are immediately transmitted to the country's other markets" (Sendhil, *et al.*, 2014; Singla, 2015). Onion prices are more volatile than non-farm commodities due to inherently unstable production. India is the second largest producer of onion after China & it accounts 40.74% of the total annual production of the onion among top five onion producing countries of the world as mentioned in Table 1.

**Table 1: Top five onion producing countries of the world**

| Country | Production (Tonnes) | Share % |
|---|---|---|
| **China** | 24775344 | 45.73 |
| **India** | 22071000 | 40.74 |
| **USA** | 3284420 | 06.06 |
| **Iran** | 2406718 | 04.44 |
| **Russia** | 1642106 | 03.03 |
| **Total** | 54,179,588 | 100.00 |

Source: (FAOSTAT 2018).

In India, Maharashtra is the leading producer of onion in terms of area and production which accounts 29.55% share of the total onion production followed by M.P (16.97%), Karnataka (11.63 %), Rajasthan (6.57%) and Gujarat (5.90%) of India in the year 2018-19 as showed in the Table 2.

**Table 2: Percentage share of area & production under major onion producing states (2018-19)**

| | | | | **Area-000 Hectare** |
|---|---|---|---|---|
| **State** | **Area** | **% of All India** | **Production** | **% of All India** |
| **Maharashtra** | 501.76 | 38.15 | 6522.84 | **29.55** |
| Madhya Pradesh | 151.35 | 11.51 | 3745.47 | 16.97 |
| Karnataka | 191.34 | 14.59 | 2566.43 | 11.63 |
| Rajasthan | 64.15 | 4.88 | 1450.00 | 6.57 |
| **Gujarat** | 52.13 | 3.96 | 1303.07 | **5.90** |
| Bihar | 54.60 | 4.15 | 1261.45 | 5.72 |
| Andhra Pradesh | 43.87 | 3.34 | 1078.22 | 4.89 |
| Haryana | 29.75 | 2.26 | 690.99 | 3.13 |
| West Bengal | 35.20 | 2.68 | 633.60 | 2.87 |
| Uttar Pradesh | 26.85 | 2.04 | 439.64 | 1.99 |
| Others | 163.75 | 12.45 | 2379.43 | 10.87 |
| **All India** | **1315.24** | **100.00** | **22071.24** | **100.00** |

Source: Department of Agriculture, Cooperation & Farmers Welfare

Because of the spillover impact to other onion markets, the rapid increase in onion market price affects both producers and consumers, resulting in significant inflation in the economy. One of the most essential responsibilities for market players is to understand the price transmission mechanism, which allows prices to move instantly from one market to another which helps in price control. The marketing of onions in the country has always been a source of concern for both farmers and consumers due to a lack of market intelligence and uncertainty about future pricing. In this background, an attempt has been made to examine market integration among major Indian onion markets. In literature, Granger (1969), Engle and Granger (1987), Johansen (1991, 1995, and 1996), and others set the basis for co-integration analysis in econometric modelling. Accordingly, Paul *et al.* (2016) studied "the effectiveness of integration in price forecasting for onion in selected markets of Delhi". Wani *et al*. (2015a,b,c) described "market integration as a measure of the extent to which demand and supply in one location are transmitted to another".

The present study uses Augumented Dicky fuller test, Johnasen cointegration and Granger casuality test for estimating the market integration and studying the direction of causality in the long run in the selected markets.

**Methodology**

Time series data of monthly duration for the prices of onion were collected from the portal of NHRDF from the year January 2004 to December 2020 for the study under consideration. Seven national market from various states of India were selected on the basis of highest tri-anium ending average of onion arrivals in the market for the last three year from 2017 to 2020. Pimpalgaon, Lasalgaon, Solapur, Pune markets from Maharashtra, Bangalore market from Karnataka, Hyderabad market from Telangana & Indore market from Madhya Pradesh were selected as national market respectively for the study. The data collected for the study was analysed using the R, E-views 11 & SAS software, respectively.

**Techniques and Tools Used**

**Unit root test**

Stationarity in the data series explains the order of differences & it is utmost important for the markets to be in the same order in order to perform co-integration between market pairs. It is very important to test whether or not the time series is stationary because if a time series is not stationary, its behaviour can only be studied for the time period under consideration, it cannot be generalized to other periods & thus one cannot predict such a time series data. So in order to test the data is stationary or having unit root, the famous test known as Augmented Dickey-Fuller (ADF) (Dickey, 1979) test is used.

The presence of unit root (non-stationary) in the underlying series is tested by performing Augmented Dickey-Fuller test using the following regression:

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

Where, $Y_{it}$ = Price of a commodity in a given market 'i' at a time 't'; $\Delta Y_{t-i} = (Y_{t-1} - Y_{t-2})$ (t-i – lagged prices & Δ is Differenced series); $e_t$ is pure white noise error-term, $\alpha$ is the drift parameter, T is the time trend effect, $\beta_i, \delta_i$ & $b_i$ is coefficients. The null hypothesis that ρ = 0; signifying presence of unit root, *i.e.*, the time series is non-stationary and the alternative hypothesis is ρ < 0 signifying the time series is stationary, therefore, rejecting the null hypothesis.

**Johansen Co-integration Test**

The ADF test was supplemented by Johansen-Juselius Maximum Likelihood Method. The maximum likelihood (ML) approach of cointegration is used to examine the long-run relationship between wholesale prices of onion in selected markets of India (Johansen and Juselius, 1990).

The Johansen technique examines a Vector Auto Regression (VAR) model of $Y_t$, an (n x l) vector of variables that are integrated of the order one - I time series. This VAR can be expressed as equation:

$$Y_t = \mu + \sum_{i=1}^{p-1} \Gamma_i Y_{t-1} + \Pi Y_{t-1} + \varepsilon_t \qquad (2)$$

Where, Γ & Π are matrices of parameters, p is the number of lags (selected on the basis of Akaike information criterion), $\varepsilon_t$ is an (n x l) vector of innovations. Both Γ and Π are the n*n matrixes of the coefficient conveying the short and long run information respectively and $\varepsilon_t$ is the n-dimensional vector of the residuals that is identical and independent distributed. To measure the number of cointegrating vectors, Johansen and Juselius (1990) developed two likelihood ratio test statistics (Trace and Max Eigen test statistics) represented as equations:

$$J_{trace} = -T \sum_{i=r+1}^{n} \ln(1 - \hat{\lambda}_i) \qquad (3)$$

$$J_{max} = -T \ln(1 - \hat{\lambda}_i + 1) \qquad (4)$$

Where, T is the sample size & $\widehat{\lambda}_i$ is the i$^{th}$ largest canonical correlation, r is the number cointegrated vector. r cointegrating vector(s) against the alternative hypothesis of n cointegrating relations. The Max Eigen statistic tested the null hypothesis (r =0) against the alternative (r + 1) (Gujarati, 2010).

**Granger Causality Test**

Granger causality is a statistical concept of causality that is based on prediction. According to Granger causality, if a signal X "Granger causes" (or "G-causes") a signal Y, then present & past values of X may contain information that helps predict future Y (Granger, 1969). At the same time, it is important to note that Granger causality measures precedence & information content but does not by itself indicate causality. The causality test was attempted by the equation given below:

$$\Delta Y_{it} = \beta_0 + \beta_1 Y_{i(t-1)} + \beta_2 Y_{j(t-1)} + \sum_{k=1}^{m} \delta_k \Delta y_{i(t-k)} \sum_{h-1}^{n} \alpha_h \Delta y_{j(t-h)} + \varepsilon_{it} \quad (5)$$

Where, $Y_{it}$ = market 'i' at time 't', $Y_{jt}$ = market 'J' at time 't' and m & n = number of lags determined by AIC.

The null hypothesis is that X does not Granger cause Y. Rejection of the null hypothesis that αh = 0 where h =1, 2, 3,…, n indicates that prices in market " j" Granger-cause prices in market 'I'. If prices in market 'I' also Granger-cause prices in market 'j', then prices are determined by a simultaneous feed-back mechanism (SFM). This is the phenomenon of bi-directional causality. If the Granger causality runs one way, it is called unidirectional Granger-causality & the market which Granger causes the other is tagged the exogenous market (Gujarati, 2010).

**Results and Discussions**

The descriptive statistics of the selected markets prices are reported in Table 3. High instability/ volatility of prices has been remained in case of Pimpalgaon market (87.17%) followed by Lasalgaon (83.72%) and Bangalore (82.55%) market while comparatively stable volatility found in case of Hyderabad (75.13%) market. The probable reason behind such instability is that the Nasik belt of Maharashtra is known for the highest onion producing belt in India, any factor whether it is seasonal change or loss of crop may result in such volatility and affects the other onion wholesale markets. The skewness value for all the markets show presence of asymmetric behaviour in them and also the coefficient of kurtosis is very high in Bangalore market followed by Pimpalgaon and Pune market which reflect the leptokurtic distribution and high degree of extreme values. Change in the pattern of arrivals in the market affects the price behavioural pattern as well as lack of proper supply of information to other wholesale markets may result in such changes.

**Table 3: Descriptive statistics of onion prices in selected national markets**

| Markets | Pimpal. | Lasal. | Solapur | Pune | Bangalore | Hydera. | Indore |
|---|---|---|---|---|---|---|---|
| **Mean** | 1070.44 | 1085.91 | 750.86 | 1063.50 | 1203.69 | 1126.49 | 902.22 |
| **Max** | 5934.00 | 5105.00 | 3520.00 | 5008.00 | 9200.00 | 5159.05 | 3950.00 |
| **Min** | 163.00 | 151.00 | 122.00 | 223.00 | 320.00 | 238.00 | 158.00 |
| **Variance** | 870597 | 826540 | 370485 | 733302 | 987389 | 716260 | 540357 |
| **St. D.** | 933.06 | 909.14 | 608.67 | 856.33 | 993.67 | 846.32 | 735.09 |
| **C.V %** | 87.17 | 83.72 | 81.06 | 80.52 | 82.55 | 75.13 | 81.48 |
| **Skewness** | 2.378 | 2.052 | 2.020 | 2.171 | 3.780 | 2.129 | 1.892 |
| **Kurtosis** | 6.484 | 4.377 | 4.352 | 5.243 | 22.728 | 5.193 | 3.536 |

*Note: Pimpal.-Pimpalgaon, Lasal.-Lasalgaon, Hydera.-Hyderabad, St. Deviation- Standard Deviation*

**Unit root test**

Typically, the Johansen's procedure necessitated that the time series should be integrated at order one, *i.e*., I (1). The time series data of onion prices in the selected markets were tested using the Augmented Dickey-Fuller (ADF) test to see whether they are stationary at their current levels, followed by their differences. The null hypothesis of both the tests is accepted or rejected based on the critical value and corresponding probability value. The lag length was selected using the Akaike Information Criterion (AIC). Results from the analysis mentioned in Table 4 revealed that prices were found to be non-stationary at their level for all the selected national markets of onion but become stationary after first differencing. Hence, the value of d was taken as 1 *i.e*., I(1) for all the markets.

**Table 4: ADF test results of onion prices for selected national markets**

| **Markets** | **ADF** | |
|---|---|---|
| | **Level** | **First Difference** |
| Pimpalgaon | -3.96 | -5.42* |
| Lasalgaon | -3.76 | -5.30* |
| Solapur | -3.81 | -5.05* |
| Pune | -3.56 | -5.38* |
| Bangalore | -3.71 | -5.27* |
| Hyderabad | -3.94 | -5.21* |
| Indore | -3.85 | -5.40* |

*Null Hypothesis: Series has a unit root*
*Statistical critical value of 1%=-3.4625, 5 per cent = -2.8756*
** indicates of significance of values at 5 per cent level*

**Johansen's Co-integration Analysis**

"Co-integration between the stationary price series was then evaluated using Johansen's Trace and Maximum Eigen-value tests as the following step. The Johansen procedure for the onion markets of India was applied by following the three steps firstly appropriate lag length was chosen as suggested by the various lag length criterion. Secondly, the order of integration was confirmed by using the ADF and In the third step, two tests, *i.e.*, trace and max Eigen statistics of Johansen's approach based on the vector autoregressive model (VAR) were put into the application to analyze the co-integrating vectors between the selected onion markets. Table 5 and Table 6 shows the results of Johansen's maximum likelihood tests (trace test and maximum eigen-value). The trace test and maximum eigen-value pits no cointegration (r = 0) against the alternative hypothesis (r ≥1) that at least one co-integrated equation predominated in the VAR system". (Ahmed et. al. 2017)

**Table 5: Unrestricted co-integration rank test (Trace) between onion markets**

| Hypothesized No. of CE(s) | Eigen-Value | Trace Statistic | 0.05 Critical Value | p-Value |
|---|---|---|---|---|
| None * | 0.63 | 830.38* | 239.23 | 0.0001 |
| At most 1 * | 0.31 | 266.85* | 95.75 | 0.0000 |
| At most 2 * | 0.23 | 191.86* | 69.81 | 0.0000 |
| At most 3 * | 0.22 | 136.95* | 47.85 | 0.0000 |
| At most 4 * | 0.17 | 85.51* | 29.79 | 0.0000 |
| At most 5 * | 0.12 | 47.21* | 15.49 | 0.0000 |
| At most 6 * | 0.09 | 20.90* | 3.841 | 0.0000 |

*Note: Trace test indicates at least 7 co-integrating eq.(s) at the 5 per cent level*
** denotes rejection of hypothesis at 5 per cent level of significance*

**Table 6: Unrestricted co-integration rank test (Maximum-Eigen value) between onion markets**

| Hypothesized No. of CE(s) | Eigen-Value | Max-Eigen Statistic | 0.05 Critical Value | p-Value |
|---|---|---|---|---|
| None * | 0.638 | 205.41* | 64.50 | 0.0001 |
| At most 1 * | 0.310 | 74.99* | 40.07 | 0.0000 |
| At most 2 * | 0.238 | 54.91* | 33.87 | 0.0000 |
| At most 3 * | 0.224 | 51.43* | 27.58 | 0.0000 |
| At most 4 * | 0.172 | 38.29* | 21.13 | 0.0001 |
| At most 5 * | 0.122 | 26.31* | 14.26 | 0.0004 |
| At most 6 * | 0.098 | 20.90* | 3.841 | 0.0000 |

*Note: Max-Eigen statistics indicates at least 7 co-integrating eq.(s) at the 5% level,*
** denotes rejection of hypothesis at 5 per cent level of significance*

The result clearly indicates the existence of at least seven co-integration equation. "The Trace and Maximum Eigen-value tests results showed that the onion prices in India moves together in the long run equilibrium. As a result, it may be stated that India's onion markets are well-functioning. Additionally, the Johansen's Trace and Maximum Eigen-value tests indicate that in these onion markets pairs, wholesale prices are competitive. The findings are consistent with the majority of regional studies, which indicated that the domestic onion markets are well-functioning and that prices are well-transmitted and cointegrated". (Reddy *et al.*, 2012; Sendhil *et al.*, 2014; Rajendran, 2015). Prices are governed not only based on market arrivals but also several factors prevailing in other markets like varieties, appearance, moisture content, colour, size and shape of the produce. However, the flow of market information across markets will help to realize the law of one price in onions.



**Granger causality test**

After confirming the integration of prices series, in the next step, pair-wise Granger causality test was performed for seven onion markets to comprehend causal relation between them.

**Table 7: Results of pair wise Granger causality test of onion prices for selected national markets**

| Null Hypothesis | Obs. | F-Statistic | Prob. | Dir. |
|---|---|---|---|---|
| LASALGAON does not Granger Cause PIMPALGAON | 203 | 26.44* | 6.E-07 | **Uni** |
| PIMPALGAON does not Granger Cause LASALGAON | | 0.19 | 0.65 | |
| SOLAPUR does not Granger Cause PIMPALGAON | 203 | 29.40* | 2.E-07 | **Uni** |
| PIMPALGAON does not Granger Cause SOLAPUR | | 0.63 | 0.42 | |
| PUNE does not Granger Cause PIMPALGAON | 203 | 1.84 | 0.17 | **Uni** |
| PIMPALGAON does not Granger Cause PUNE | | 8.68* | 0.03 | |
| BANGALORE does not Granger Cause PIMPALGAON | 203 | 0.09 | 0.97 | **Uni** |
| PIMPALGAON does not Granger Cause BANGALORE | | 16.42* | 7.E-05 | |
| HYDERABAD does not Granger Cause PIMPALGAON | 203 | 4.82* | 0.02 | **Bi** |
| PIMPALGAON does not Granger Cause HYDERABAD | | 22.98* | 3.E-06 | |
| INDORE does not Granger Cause PIMPALGAON | 203 | 1.21 | 0.27 | **Uni** |
| PIMPALGAON does not Granger Cause INDORE | | 34.97* | 1.E-08 | |
| SOLAPUR does not Granger Cause LASALGAON | 203 | 24.05* | 2.E-06 | **Uni** |
| LASALGAON does not Granger Cause SOLAPUR | | 0.29 | 0.59 | |
| PUNE does not Granger Cause LASALGAON | 203 | 0.08 | 0.76 | **Uni** |
| LASALGAON does not Granger Cause PUNE | | 28.15* | 3.E-07 | |
| BANGALORE does not Granger Cause LASALGAON | 203 | 0.20 | 0.65 | **Uni** |
| LASALGAON does not Granger Cause BANGALORE | | 42.64* | 5.E-10 | |

| | | | | |
|---|---|---|---|---|
| HYDERABAD does not Granger Cause LASALGAON | 203 | 0.88 | 0.34 | |
| LASALGAON does not Granger Cause HYDERABAD | | 21.93* | 5.E-06 | **Uni** |
| INDORE does not Granger Cause LASALGAON | 203 | 0.19 | 0.66 | |
| LASALGAON does not Granger Cause INDORE | | 41.48* | 9.E-10 | **Uni** |
| PUNE does not Granger Cause SOLAPUR | 203 | 0.99 | 0.32 | |
| SOLAPUR does not Granger Cause PUNE | | 23.82* | 2.E-06 | **Uni** |
| BANGALORE does not Granger Cause SOLAPUR | 203 | 1.61 | 0.20 | |
| SOLAPUR does not Granger Cause BANGALORE | | 26.34* | 7.E-07 | **Uni** |
| HYDERABAD does not Granger Cause SOLAPUR | 203 | 0.11 | 0.73 | |
| SOLAPUR does not Granger Cause HYDERABAD | | 26.43* | 6.E-07 | **Uni** |
| INDORE does not Granger Cause SOLAPUR | 203 | 5.46* | 0.02 | |
| SOLAPUR does not Granger Cause INDORE | | 74.96* | 2.E-15 | **Bi** |
| BANGALORE does not Granger Cause PUNE | 203 | 1.37 | 0.24 | |
| PUNE does not Granger Cause BANGALORE | | 0.94 | 0.33 | **-** |
| HYDERABAD does not Granger Cause PUNE | 203 | 15.19* | 0.01 | |
| PUNE does not Granger Cause HYDERABAD | | 9.40* | 0.02 | **Bi** |
| INDORE does not Granger Cause PUNE | 203 | 11.40* | 0.09 | |
| PUNE does not Granger Cause INDORE | | 16.44* | 7.E-05 | **Bi** |
| HYDERABAD does not Granger Cause BANGALORE | 203 | 14.96* | 0.01 | **Bi** |
| BANGALORE does not Granger Cause HYDERABAD | | 15.13* | 0.01 | **Bi** |
| INDORE does not Granger Cause BANGALORE | 203 | 35.44* | 1.E-08 | |
| BANGALORE does not Granger Cause INDORE | | 27.97* | 3.E-07 | **Bi** |
| INDORE does not Granger Cause HYDERABAD | 203 | 13.38* | 0.03 | |
| HYDERABAD does not Granger Cause INDORE | | 20.68* | 9.E-06 | **Bi** |

**indicate rejection of hypothesis at 5 per cent level of significance*



The results presented in Table 7 explicates that the few market pairs such as Hyderabad-Pimpalgaon, Indore- Solapur, Hyderabad-Pune, Indore-Pune, Hyderabad-Bangalore, Indore-Bangalore, Indore-Hyderabad showed Bi-directional causality. In these situations, the former market in each pair granger causes the latter market's wholesale price formation, which then gives feedback to the former market. The rest of the market pairs have unidirectional causality. No causal relationship was found between Bangalore and Pune market and *vice versa*. Different markets of onion were closely linked with each other for the movement of Onion prices which shows long-run relationship with the co-integrating markets

**Conclusion and Policy Implications**

The co-integration and price transmission of wholesale onion prices in seven major Indian marketplaces namely Pimpalgaon, Lasalgaon, Solapur, Pune, Bangalore, Hyderabad and

Indore, were investigated in this study. All of the price series in the study state were found to be stationary, indicating that some onion markets were highly integrated and had a long-run price relationship. It is seen that, Lasalgaon market causes the prices of majority of the markets under study in uni-directional manner whereas bi-directional causality has been found between few markets pairs. It indicates that Lasalgaon market is the dominating market in the price channel. The main reason behind the domination of Lasalgaon market is because Nashik district of Maharashtra is the main production hub in comparison to other. In order to continue the present system of market integration, there is need to establish cells to generate market information and market intelligence which would provide a better platform for guiding the farmers in marketing their produce.

As a result, onion markets in India are highly cointegrated, implying that the government should continue to encourage the private sector's freedom to operate. The findings of this study might be beneficial in the development of a wholesale market network across the state to improve market integration and price transmission. Market integration is an important tool and prerequisite for effective marketing. This will assist to promote market integration in the long run by establishing marketing infrastructure, pricing information channels, road networks, and transportation facilities, which will help to lower transportation costs and boost inter-regional commerce. These modifications will prevent inefficient onion crop area allocation in India and increase the efficiency of the existing inefficient onion markets. Because the major onion markets in India have a strong long-run price transmission relationship, data on onion prices must be collected and disseminated to both consuming and producing markets. In addition, establishing a real-time Market Information Cell in Major onion producing marketplaces can aid merchants and farmers in analyzing pricing information in other markets throughout the state and country. Farmers can reallocate resources and improve production using this knowledge, and merchants can transfer commodity supply to other markets where there is a local scarcity, perhaps resulting in higher pricing.



**Source of research article:**

This paper is part of the thesis submitted to Department of Agricultural Economics, B. A. College of Agriculture, Anand Agricultural University, Anand- 388110 for the completion of M.Sc. (Agri.) degree during 2021.

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