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Co-integration and Causality Analysis in Selected Onion Markets of Western Maharashtra

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ABSTRACT: *The study has investigated market integration across ten major onion markets, viz. Ahmednagar, Yeola, Pune, Lasalgaon, Pimpalgaon, Lonand, Kolhapur, Solapur, Dhule and Jalgaon by adopting Johansen's multivariate co-integration approach. The study has confirmed the presence of co-integration, implying the long-run price association among the markets. To get the additional evidence as to whether and in which direction price transmission is occurring between the market pairs, Granger causality test has been used, which has confirmed Pune and Pimpalgaon to be the price-determining market. Yeola has been found comparatively more efficient as it has depicted most bidirectional causal relations with other markets. The market pairs: Kolhapur-Ahmednagar, Dhule-Kolhapur, Dhule-Solapur, Jalgaon-Kolhapur, Jalgaon-Solapur, have not shown any causal relation between them, but the magnitude of price transmission has been found relatively low in some market pairs that are spatially integrated. The major implication of the study is for the designing of a network of agricultural wholesale markets across the region at almost equal distance from each other to enhance the market integration and better price transmission among them.*

Key words: *Onion markets, co-integration, Granger causality, price transmission*

JEL Classification: *C01, C22, Q13*

INTRODUCTION

The literature on efficiency of agricultural markets has revealed that there are several impediments to the efficient functioning of these markets in the developing economies like India. The continuing debate concerning the appropriate agricultural marketing policies, government intervention in the marketplace, determinants of agricultural marketing efficiency, and the need to estimate the effects of these determinants have made it necessary for the researchers to either modify the traditional techniques or develop methods that would enable analysis of market competence. An intrusion by the government in marketing may be justified if it remedies the nearby imperfections and does not augment distortions in the market functioning. To monitor whether the government strategy has perked up market functioning or not, is a complex phenomenon in the actual sense. However, one way to throw some light on this issue is to analyze the market performance by studying market integration [7]. This market integration can be measured in terms of the strength and speed of price transmission between markets across various regions of the country [5]. The degree to which consumers and producers would benefit, depends on how domestic markets are integrated with world markets and how different regional markets are integrated with each other [2]

Although several studies have been done empirically using co-integration techniques which concern the market integration of agricultural commodities in India (Ghosh, 2003; 2011; Kar *et al.*, 2004; Jha *et al.*, 2005; Yogisha, 2005; Jayasuriya *et al.*, 2007; Shenoy, 2008; Acharya *et al.*, 2012; Reddy *et al.*, 2012; Sekhar, 2012), only a little work has been carried out on the empirical evaluation of Onion market integration. The study by Deodhar *et al.* (2006) on market integration across the wholesale Onion markets in India has found that the markets are not integrated, but the main drawback of this study was the selection of period for the study. The selected study period had witnessed the lowest domestic

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Onion production in India for the past two decades and imports of Onion were also lowest due to 100 per cent tariff rates on Onion till 1999. On the other hand, Kar *et al.* (2004) have reported that the Chennai, Delhi and Mumbai wholesale Onion markets are well integrated. Similarly, Vasisht *et al.* (2008) have found that the prices of fruits and vegetables in major wholesale markets of India were highly volatile, but the less-perishable commodities likeap ple were found to have the presence of long-run association across some of the state level markets. The controversy of these past studies leaves a little justification whether or not Onion markets are integrated in India. While there is much emphasis on the area and production of Onions in India, relatively little is known about how price transmission takes place in the domestic Onion markets. This information is important for Onion producers and other players in Onion value chain since it influences their marketing decisions (buying and selling), which in turn, influences the assessments related to logistical matters and ultimately the export potential of Onions from India. The Onion producers are incapable to precisely base their marketing decisions on the price information they obtain from the markets in India (Kavitha, 2005). Producers do not have awareness on the concrete flow of information and products across the Onion markets. Consequently, Onion farmers are unable to specialize and benefit from the gains of trade (Deodhar *et al*., 2007). They do not allocate the resources efficiently and the produce may be sent to markets having oversupply and lower prices, instead of moving to the markets with shortage facilities and higher prices (Kavitha, 2005). On the other hand, the increasing demand for imported Onions indicates a growing consumption pattern and shift of consumers' preference from domestic to foreign produce, and thus witnessing a threat to the domestic industry, especially since 1999 when the tariffs on most of the agricultural commodities were either completely removed or lowered to allow import of foreign produce, including Onions. Against this backdrop, the present study has analyzed the market integration using the Johansen's co-integration method, determination of Granger causal directions among the major wholesale Onion markets of India.

DATA AND METHODOLOGY

The data on monthly average wholesale Onion price (in Rs./100 kg) in Ahmedabad, Bengaluru, Delhi, Hyderabad and Kolkata markets from January, 2003 to December, 2013 were taken from the National Horticulture Board, Government of India. All the series were transformed into natural log-form to eliminate variations in movement due to level differences. The analytical techniques used in the study are described below.

Augmented Dickey-Fuller (ADF) Unit Root Test

An implicit assumption in Johansen's co-integration approach is that the variables should be non-stationary at level, but stationary after first differencing. The Augmented Dickey-Fuller test is utilized to check the order of integration by using the model (1):

$$\Delta Y_t = \alpha + \delta T + \beta_1 Y_{t-1} + \sum_{i=1}^{p} \beta_1 \Delta Y_{t-1} + \varepsilon_t \quad (1)$$

where, $\Delta Yt = Yt - Yt - 1$, $\Delta Yt - 1 = Yt - 1 - Yt - 2$, and $\Delta Yt - 2 = Yt - 2 - Yt - 3$, etc., ε_t is pure white noise term, α is the constant-term, T is the time trend effect, and p is the optimal lag value which is selected on the basis of Schwartz information criterion1 (SIC). The null hypothesis is that $\beta 1$, the coefficient of $Yt - 1$ is zero. The alternative hypothesis is: $\beta 1 < 0$. A non-rejection of the null hypothesis suggests that the time series under consideration is non-stationary[1]

Co-integration Analysis Using Johansen

The Johansen procedure examines a vector auto regressive (VAR) model of Yt, an (n × 1) vector of variables that are integrated of the order one— I (1) time series. This VAR can be expressed as Equation (2):

$$\Delta Y_1 = \mu + \sum_{i=1}^{p-1} \Gamma_i Y_{r-1} + \Pi Y_{r-1} + \varepsilon_r \quad (2)$$

where, Γ and Π are matrices of parameters, p is the number of lags (selected on the basis of Schwarz information criterion), ε_t is an (n × 1) vector of innovations. The presence of at least one cointegrating relationship is necessary for the analysis of long-run relationship of the prices to be plausible. To detect the number of co-integrating vectors, Johansen proposed two likelihood ratio tests: trace test and maximum eigen value test, shown in Equations (3) and (4), respectively.

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

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

where, T is the sample size and $\hat{\lambda}$ i is the *ith* largest canonical correlation. The trace test examines the null hypothesis of r cointegrating vectors against the alternative hypothesis of n cointegrating vectors. The

maximum eigen value test, on the other hand, tests the null hypothesis of *r* cointegrating vectors against the alternative hypothesis of *r+1* cointegrating vectors. [2]

Granger Causality Test

The Granger causality test conducted within the framework of a VAR model is used to test the existence and the direction of long-run causal price relationship between the markets (Granger, 1969). It is an F-test of whether changes in one price series affect another price series. Taking the causality relationship between Delhi and Ahmedabad wholesale Onion markets as an example, the test was based on the following pairs of OLS regression equations through a bivariate VAR:

$$P\ln D_t = \sum_{i=1}^{m} \alpha_i P\ln D_{t-i} + \sum_{i=1}^{m} \beta_j P\ln A_{t-j} + \varepsilon_{1t} \quad (5)$$

$$P\ln A_t = \sum_{i=1}^{m} \Upsilon_i P\ln A_{t-i} + \sum_{i=1}^{m} \delta_j P\ln D_{t-j} + \varepsilon_{2t} \quad (6)$$

where, *D* and *A* are Delhi and Ahmedabad markets, *P* ln stands for price series in logarithm form and *t* is the time trend variable. The subscript stands for the number of lags of both variables in the system. The null hypothesis in Equation (5), i.e. *H0:* $\beta 1 = \beta 2 = ... = \beta j = 0$ against the alternative, i.e., *H1*: Not *H0*, is that *P* ln *At* does not Granger cause *P* ln *Dt*. Similarly, testing *H0:* $\delta 1 = \delta 2 = ... = \delta j = 0$ against *H1*: Not *H0* in Equation (6) is a test that *P* ln *Dt* does not Granger cause *P* ln *At*. In each case, a rejection of the null hypothesis will imply that there is Granger causality between the variables (Gujarati, 2010).

RESULTS AND DISCUSSION

Unit Root Test Results

The results of the Augmented Dickey-Fuller (ADF) unit root test applied at level and first difference to the logarithmically transformed prices of onion are given in Table 1. The empirical evidence suggests that price series had unit root problem at their level form. The null hypothesis of the unit root at level form cannot be rejected for all price series as the absolute values of the ADF statistics are well below the 5 per cent critical values of the test statistics. Thus, it is concluded that all the price series are non-stationary at their level forms. In order to test the level or number of unit roots in the data, a unit root test of first difference was conducted, which showed the number of unit roots to be equal to one, since the data became stationary after the first difference as absolute values of the ADF statistics were now greater than the 5 per cent critical values of the test statistics. With the proof that the price series were non-stationary and integrated of the order 1, test for co-integration among the selected Onion markets using Johansen's maximum likelihood approach was applied.

Table 1
ADF unit root test results for prices of onion in selected markets of Western Maharashtra

Sr. No.	*Market*	*At level/ first difference*	*T-cal.*	*(Prob.*)*	*Remarks*
1	**Ahmednagar**	ln Ahmednagar	3.3192	0.0012	Non-stationary
		Δ ln Ahmednagar	-4.2621	(0.0000)	Stationary
2	**Pimpalgaon**	ln Pimpalgaon	-2.8860	0.0072	Non-stationary
		Δ ln Pimpalgaon	-3.5971	(0.0000)	Stationary
3	**Lasalgaon**	ln Lasalgaon	-3.4870	0.0262	Non-stationary
		Δ ln Lasalgaon	-5.7263	(0.0000)	Stationary
4	**Yeola**	ln Yeola	-3.4865	0.0016	Non-stationary
		Δ ln Yeola	-4.0729	(0.0000)	Stationary
5	**Pune**	ln Pune	-4.2920	0.0025	Non-stationary
		Δ ln Pune	-5.5322	(0.0000)	Stationary
6	**Lonand**	ln Lonand	-3.4944	0.0060	Non-stationary
		Δ ln Lonand	-4.3655	(0.0000)	Stationary
7	**Solapur**	ln Solapur	-3.8914	0.0013	Non-stationary
		Δ ln Solapur	-4.1567	(0.0000)	Stationary
8	**Kolhapur**	ln Kolhapur	-2.0049	0.0473	Non-stationary
		Δ ln Kolhapur	-8.6164	(0.0000)	Stationary
9	**Dhule**	ln Dhule	-3.6621	0.0028	Non-stationary
		Δ ln Dhule	-4.5286	(0.0000)	Stationary
10	**Jalgaon**	ln Jalgaon	-3.2516	0.0015	Non-stationary
		Δ ln Jalgaon	-4.0729	(0.0000)	Stationary

Notes: 1. The asterisks ** indicate that unit root at level or in the first differences were rejected at 1 per cent as well as at 5 per cent significance. The (prob.*) denotes MacKinnon (1996) one-sided *p*-values.
2. 'ln' denotes wholesale price in logarithmic form and ??ln denotes the price series in logarithm form after first difference.

Co-integration Test Results

The results of Johansen's maximum likelihood tests (maximum eigen-value and trace test) are given in Table 2. To check the first null hypothesis that the variables were not cointegrated ($r = 0$), trace and eigen-value statistics were calculated, both of which rejected the null hypotheses as maximum eigen-value and trace test statistics values were higher than 5 per cent critical values and accepted the alternative of one or more cointegrating vectors. Similarly, the null hypotheses: $r \leq 1$, $r \leq 2$. $r \leq 3$, $r \leq 4$, $r \leq 5$, $r \leq 6$, $r \leq 7$, $r \leq 8$ and $r \leq 9$ from both statistics were rejected against their alternative hypotheses of $r \geq 1$, $r \geq 2$, $r \geq 3$, $r \geq 4$, $r \geq 5$, $r \geq 6$, $r \geq 7$, $r \geq 8$ and $r \geq 9$, respectively. The null hypothesis $r \geq 9$ from both the tests (trace test and maximum eigen-value test) were accepted and their alternative hypotheses ($r = 10$) were rejected as the trace value and maximum eigen-value were well below than their corresponding critical values at 5 per cent level of significance. Both these tests confirmed that all the five selected onion markets had 9 cointegrating vectors out of 10 cointegrating equations, indicating that they are well integrated and price signals are transferred from one market to the other to ensure efficiency. Thus, Johnson co-integration test has shown that even though the selected onion markets in Western Maharashtra are geographically isolated and spatially segmented, they are well-connected in terms of prices of onion, demonstrating that the selected onion markets have long-run price linkage across them.

Table 2
Overall co-integration in selected onion markets of Western Maharashtra

Sr. No.	H_0	H_A	*Statistics*	*C.V. (5%)*
		Trace Test		
1	r = 0	r ≥ 1	615.79*	244.12
2	r ≤ 1	r ≥ 2	436.73*	201.92
3	r ≤ 2	r ≥ 3	327.68*	165.58
4	r ≤ 3	r ≥ 4	251.08*	131.70
5	r ≤ 4	r ≥ 5	184.15*	102.14
6	r ≤ 5	r ≥ 6	130.70*	76.07
7	r ≤ 6	r ≥ 7	86.74*	53.12
8	r ≤ 7	r ≥ 8	45.57*	34.91
9	r ≤ 8	r ≥ 9	21.64*	19.96
10	r ≤ 9	r = 10	1.73	9.24
		Maximum eigen – value Test		
1	r = 0	r ≥ 1	236.54*	257.68
2	r ≤ 1	r ≥ 2	196.37*	215.74
3	r ≤ 2	r ≥ 3	159.48*	177.20
4	r ≤ 3	r ≥ 4	126.58*	143.09
5	r ≤ 4	r ≥ 5	97.18*	111.01
6	r ≤ 5	r ≥ 6	71.76*	84.45
7	r ≤ 6	r ≥ 7	49.65*	60.16
8	r ≤ 7	r ≥ 8	32.16*	41.07
9	r ≤ 8	r ≥ 9	17.85*	24.60
10	r ≤ 9	r = 10	7.52	12.97

Note: *denotes rejection of the null hypothesis at 5 per cent level of significance.

Table 3
Results of causality test for selected onion Markets of Western Maharashtra.

Sr. No.	*Null Hypothesis*	*F-Statistic*	*Probability*	*Grangercause*	*Direction*
1	Yeola Does Not Granger Cause Ahmednagar	54.8381	0.0000002**	Yes	Bidirectional
	Ahmednagar Does Not Granger Cause Yeola	18.7669	0.00000009**	Yes	
2	Pune Does Not Granger Cause Ahmednagar	15.2612	0.000001**	Yes	Bidirectional
	Ahmednagar Does Not Granger Cause Pune	7.80223	0.0007**	Yes	
3	Lasalgaon Does Not Granger Cause Ahmednagar	37.8412	0.00003**	Yes	Bidirectional
	Ahmednagar Does Not Granger Cause Lasalgaon	24.6908	0.000000001**	Yes	
4	Pimpalgaon Does Not Granger Cause Ahmednagar	16.0112	0.0000008**	Yes	Unidirectional
	Ahmednagar Does Not Granger Cause Pimpalgaon	6.17028	0.0029	No	
5	Lonand Does Not Granger Cause Ahmednagar	5.79231	0.004**	Yes	Unidirectional
	Ahmednagar Does Not Granger Cause Lonand	20.6700	0.00000002	No	
6	Kolhapur Does Not Granger Cause Ahmednagar	10.1941	0.00009	No	None
	Ahmednagar Does Not Granger Cause Kolhapur	24.0502	0.000000002	No	
7	Dhule Does Not Granger Cause Ahmednagar	15.7551	0.0000009	No	Unidirectional
	Ahmednagar Does Not Granger Cause Dhule	11.0623	0.00004**	Yes	
8	Solapur Does Not Granger Cause Ahmednagar	15.3917	0.000001**	Yes	Bidirectional
	Ahmednagar Does Not Granger Cause Solapur	14.2940	0.000003**	Yes	
9	Jalgaon Does Not Granger Cause Ahmednagar	21.9525	0.000000009	No	Unidirectional
	Ahmednagar Does Not Granger Cause Jalgaon	10.2959	0.00008**	Yes	
10	Pune Does Not Granger Cause Yeola	11.8636	0.00002**	Yes	Bidirectional
	Yeola Does Not Granger Cause Pune	15.5142	0.000001**	Yes	
11	Lasalgaon Does Not Granger Cause Yeola	4.85683	0.0095**	Yes	Bidirectional
	Yeola Does Not Granger Cause Lasalgaon	11.7278	0.00002**	Yes	
12	Pimpalgaon Does Not Granger Cause Yeola	18.4492	0.0000001**	Yes	Bidirectional
	Yeola Does Not Granger Cause Pimpalgaon	16.1722	0.0000007**	Yes	

contd. table

Sr. No.	Null Hypothesis	F-Statistic	Probability	Grangercause	Direction
13	Lonand Does Not Granger Cause Yeola	5.64725	0.0046**	Yes	Bidirectional
	Yeola Does Not Granger Cause Lonand	19.3153	0.00000006**	Yes	
14	Kolhapur Does Not Granger Cause Yeola	16.8480	0.0000004	No	Unidirectional
	Yeola Does Not Granger Cause Kolhapur	10.7146	0.00005**	Yes	
15	Dhule Does Not Granger Cause Yeola	19.5862	0.00000005**	Yes	Bidirectional
	Yeola Does Not Granger Cause Dhule	16.1346	0.0000007**	Yes	
16	Solapur Does Not Granger Cause Yeola	12.4085	0.00001**	Yes	Bidirectional
	Yeola Does Not Granger Cause Solapur	10.8068	0.00005**	Yes	
17	Jalgaon Does Not Granger Cause Yeola	10.1307	0.00009	No	Unidirectional
	Yeola Does Not Granger Cause Jalgaon	7.33016	0.001**	Yes	
18	Lasalgaon Does Not Granger Cause Pune	6.10010	0.003**	Yes	Bidirectional
	Pune Does Not Granger Cause Lasalgaon	18.5326	0.0000001**	Yes	
19	Pimpalgaon Does Not Granger Cause Pune	32.0265	0.00011**	Yes	Bidirectional
	Pune Does Not Granger Cause Pimpalgaon	12.6273	0.00001**	Yes	
20	Lonand Does Not Granger Cause Pune	4.66236	0.0113**	Yes	Bidirectional
	Pune Does Not Granger Cause Lonand	28.4495	0.0015**	Yes	
21	Kolhapur Does Not Granger Cause Pune	12.9653	0.000009**	Yes	Bidirectional
	Pune Does Not Granger Cause Kolhapur	47.6128	0.00019**	Yes	
22	Dhule Does Not Granger Cause Pune	6.44971	0.0022	No	Unidirectional
	Pune Does Not Granger Cause Dhule	25.2649	0.00091**	Yes	
23	Solapur Does Not Granger Cause Pune	7.65454	0.0008**	Yes	Bidirectional
	Pune Does Not Granger Cause Solapur	14.1519	0.000003**	Yes	
24	Jalgaon Does Not Granger Cause Pune	8.93604	0.0002	No	Unidirectional
	Pune Does Not Granger Cause Jalgaon	18.4676	0.0000001**	Yes	
25	Pimpalgaon Does Not Granger Cause Lasalgaon	19.5602	0.00000005**	Yes	Bidirectional
	Lasalgaon Does Not Granger Cause Pimpalgaon	13.6504	0.000005**	Yes	
26	Lonand Does Not Granger Cause Lasalgaon	8.57802	0.0003**	Yes	Bidirectional
	Lasalgaon Does Not Granger Cause Lonand	10.8372	0.00005**	Yes	
27	Kolhapur Does Not Granger Cause Lasalgaon	5.67511	0.0045	No	Unidirectional
	Lasalgaon Does Not Granger Cause Kolhapur	11.0622	0.00004**	Yes	
28	Dhule Does Not Granger Cause Lasalgaon	6.19427	0.0028	No	Unidirectional
	Lasalgaon Does Not Granger Cause Dhule	10.8823	0.00005**	Yes	
29	Solapur Does Not Granger Cause Lasalgaon	9.91753	0.0001**	Yes	Bidirectional
	Lasalgaon Does Not Granger Cause Solapur	6.36485	0.0024**	Yes	
30	Jalgaon Does Not Granger Cause Lasalgaon	8.16136	0.0005	No	Unidirectional
	Lasalgaon Does Not Granger Cause Jalgaon	12.1078	0.00002**	Yes	
31	Lonand Does Not Granger Cause Pimpalgaon	12.7545	0.00001**	Yes	Bidirectional
	Pimpalgaon Does Not Granger Cause Lonand	18.4924	0.0000001**	Yes	
32	Kolhapur Does Not Granger Cause Pimpalgaon	9.80841	0.0001**	Yes	Bidirectional
	Pimpalgaon Does Not Granger Cause Kolhapur	22.3682	0.000000007**	Yes	
33	Dhule Does Not Granger Cause Pimpalgaon	11.3517	0.00003	No	Unidirectional
	Pimpalgaon Does Not Granger Cause Dhule	27.5743	0.00102**	Yes	
34	Solapur Does Not Granger Cause Pimpalgaon	15.5411	0.000001**	Yes	Bidirectional
	Pimpalgaon Does Not Granger Cause Solapur	5.61341	0.0047**	Yes	
35	Jalgaon Does Not Granger Cause Pimpalgaon	13.2747	0.000007	No	Unidirectional
	Pimpalgaon Does Not Granger Cause Jalgaon	27.2412	0.00271**	Yes	
36	Kolhapur Does Not Granger Cause Lonand	2.82703	0.0634**	Yes	Bidirectional
	Lonand Does Not Granger Cause Kolhapur	9.57901	0.0001**	Yes	
37	Dhule Does Not Granger Cause Lonand	8.51761	0.0004	No	Unidirectional
	Lonand Does Not Granger Cause Dhule	7.83087	0.0007**	Yes	
38	Solapur Does Not Granger Cause Lonand	11.9366	0.00002**	Yes	Bidirectional
	Lonand Does Not Granger Cause Solapur	6.70223	0.0018**	Yes	
39	Jalgaon Does Not Granger Cause Lonand	13.0695	0.000008	No	Unidirectional
	Lonand Does Not Granger Cause Jalgaon	8.81009	0.0003**	Yes	
40	Dhule Does Not Granger Cause Kolhapur	2.97356	0.0551	No	None
	Kolhapur Does Not Granger Cause Dhule	1.43470	0.2425	No	

contd. table

Sr. No.	Null Hypothesis	F-Statistic	Probability	Grangercause	Direction
41	Solapur Does Not Granger Cause Kolhapur	12.1747	0.00002**	Yes	Bidirectional
	Kolhapur Does Not Granger Cause Solapur	3.59260	0.0307**	Yes	
42	Jalgaon Does Not Granger Cause Kolhapur	3.52216	0.0328	No	None
	Kolhapur Does Not Granger Cause Jalgaon	6.93444	0.0014	No	
43	Solapur Does Not Granger Cause Dhule	17.7974	0.0000002	No	None
	Dhule Does Not Granger Cause Solapur	6.90861	0.0015	No	
44	Jalgaon Does Not Granger Cause Dhule	9.37501	0.0002**	Yes	Bidirectional
	Dhule Does Not Granger Cause Jalgaon	9.04185	0.0002**	Yes	
45	Jalgaon Does Not Granger Cause Solapur	4.74656	0.00314	No	None
	Solapur Does Not Granger Cause Jalgaon	14.8172	0.000002	No	

Notes: The lags of the dependent variable used to obtain white-noise residuals were determined using the Schwarz Information Criterion (SIC).

** denotes rejection of the null hypothesis at 5 per cent level of significance.

Granger Causality Test

After finding co-integration among different onion markets, granger causality was also estimated between the selected pairs of onion markets in Western Maharashtra. 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 [1]. The results of granger causality tests are presented in Table 3 which shows that all the 9 F-statistics for the causality tests of wholesale prices in Pimpalgaon, Pune and Yeola market on other markets are statistically significant. The null hypothesis of no granger causality was rejected in each case for market. Besides, Hyderabad had three, Bengaluru and Ahmedabad had two each and Kolkata had one Fstatistics statistically significant on other market prices.

According to the granger causality test, there were unidirectional causalities between the market pairs: Pimpalgaon-Ahmednagar, Lonand-Ahmednagar, Dhule-Ahmednagr, Dhule-Pimpalgaon, Dhule-Pimpalgaon, Dhule-Lonand, Jalgaon-Pimpalgaon, Jalgaon-Ahmednagr, Kolhapur-Yeola, Jalgaon-Yeola,, Pune-Dhule, Pune-Jalgaon, Lasalgaon-Dhule, Lasalgaon-Jalgaon and Lasalgaon-Kolhapur wholesale markets, meaning that a price change in the former market in each pair granger causes the price formation in the latter market, whereas the price change in the latter market is not feed backed by the price change in the former market in each pair. From Table 3, it can be seen that there exists bidirectional causality between Yeola-Ahmednagar, Pune-Ahmednagar, Lasalgaon-Ahmednagar, Solapur-Ahmednagar, Pune-Yeola, Lasalgaon-Yeola, Pimpalgaon-Yeola, Lonand-Yeola, Dhule-Yeola, Solapur-Yeola, Pune-Lasalgaon, Pune-Pimplagaon, Pune-Lonand, Pune-Kolhapur, Pune-Solapur, Lasalgaon-Pimpalgaon, Lonand-Lasalgaon, Solapur-Lasalgaon, Lonand-Pimpalgaon, Kolhapur-Pimpalgaon, Solapur-Pimpalgaon, Kolhapur-Lonand, Solapur-Lonand, Kolhapur-Solapur and Jalgaon-Dhule market pairs. In these cases, the former market in each pair granger causes the wholesale price formation in the latter market which in turn provides the feedback to the former market as well. Further, some market pairs, Kolhapur-Ahmednagar, Dhule-Kolhapur, Dhule-Solapur, Jalgaon-Kolhapur, Jalgaon-Solapur, have no direct causality between them, indicating that neither any one market of them granger causes the price formation in another. In other words, there is no longrun price association between these market pairs.

Concluding Remarks and Policy Suggestions

The study has examined co-integration, causality and price transmission in selected Onion markets of Western Maharashtra. The study has confirmed the presence of co-integration, implying the long-run price association among the markets. To get the additional evidence as to whether and in which direction price transmission is occurring between the market pairs, Granger causality test has been used, which has confirmed Pune and Pimpalgaon to be the price-determining market. Yeola has been found comparatively more efficient as it has depicted most bidirectional causal relations with other markets. The market pairs: Kolhapur-Ahmednagar, Dhule-Kolhapur, Dhule-Solapur, Jalgaon-Kolhapur, Jalgaon-Solapur, have not shown any causal relation between them, but the magnitude of price transmission has been found relatively low in some market pairs that are spatially integrated. The major implication of the study is for the designing of a network of agricultural wholesale markets across the region at almost equal distance from each other to enhance the market

integration and better price transmission among them.

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