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Market Integration and Price Transmission amongst the Major Wholesale and Retail Markets of Lentil (*Lens culinaris* / *Lens esculenta*) in India

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ABSTRACT

Background: India has become self-sufficient for cereal production but is still dependent upon pulse imports for fulfilling its domestic demands. These imports are very much capable of influencing the domestic prices, so the present study was undertaken to study the integration and price transmission amongst the major lentil producing states of India i.e. Madhya Pradesh, Uttar Pradesh, West Bengal, Bihar, Rajasthan and Assam.

Methods: Out of these six states, altogether ten markets and all India average values were undertaken for the present study based on the quantum of lentil marketed and availability of data. The secondary data was collected from the Agmarknet portal for the lentil crop while Minitab and R software were used for the analysis of the retrieved data. Various techniques like Seasonal Indices (SI), unit-root test, Johansen's cointegration test and Granger causality test were applied to find the results and conclusions of this study.

Result: The results have stated that the prices of these ten wholesale and retail markets are highly integrated and most of the markets have a uni-directional relationship with each other. The wholesale and retail markets of Jaipur and Lucknow have little/no relationship with the other markets while they have a bidirectional relationship between their own wholesale and retail market prices indicating that they might be the markets where prices are discovered, as they are not found to be influenced by the other spatially separated markets.

Key words: ADF test, Granger's causality test, Johansen's cointegration test, Lentil, Market Integration, Price transmission, Unit root test.

INTRODUCTION

Lentil (*Lens culinaris* / *Lens esculenta*) is one of the major *rabi* legume crops grown in India. The pulse production during 2018-19 was estimated to be 24.02 million tonnes and the total availability was estimated to be 26.25 million tonnes. The difference between the availability and production of pulses is filled by the exports done on account for the 2.23 million tonnes (DoC, 2019). Despite the inequality between the production and availability of pulses, India exports 0.26 million tonnes of pulses to Sri Lanka, Bangladesh, Qatar, Netherlands and USA (DoC). The share of lentil/ masur in total pulse production is lowest *i.e*. 6.38 per cent and its share in imports was also found to be very low (8.80%) and its share in total pulse export was even lower (4.60%) in 2018-19. The prices of pulses are comparatively higher than the other cereals due to insufficiency of pulse production and heavy dependence on imports from major pulse producing companies. According to Agriwatch, import of lentils had increased by 1.05 per cent during February 2020 *i.e*. a total of 21471 tonnes has been imported at an average Free on Board (FOB) of $ 458.79/tonne right before the harvesting season of lentil. These imports are significantly going to affect the domestic markets and pricing of lentil, so it was necessary to study the integration and direction of price transmission amongst the major lentil markets of India. The spatial study for both the wholesale and retail prices was carried out in this study to get acquainted with the domestic wholesale and retail price patterns.

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MATERIALS AND METHODS

Data source

The study is based on the secondary data collected for the lentil/masoor dal from the Agmarknet portal. The work was carried out in the Department of Economics and Sociology, Punjab Agricultural University, Ludhiana. Time series data on average monthly prices of lentil/masoor dal were collected for 9 years, *i.e*. from January 2011 to December 2019. The six major lentil producing states of India were taken under study *i.e*. Madhya Pradesh, Uttar Pradesh, West Bengal, Bihar, Rajasthan and Assam; altogether ten markets were targeted *viz*. Agra, Bhopal, Guwahati, Indore, Jaipur, Kanpur, Kolkata, Lucknow, Patna, Varanasi along with the all India average. The data for these ten markets were collected and analysed for the present analysis. Two software were used

for the present study: Minitab was used for calculating the Seasonal Indices (SI) and R was used for unit-root test, Johansen's cointegration test and Granger causality test.

Analytical techniques

Seasonal indices (SI) were calculated to measure the intra-year/ seasonal variations in the wholesale and retail prices of lentil by not accounting for the trend element in the dataset. The sum of seasonal indices was equal to 1200, therefore no correction factor was used in this analysis. The extent of seasonal/ intra-year wholesale and retail price variation for all the markets were estimated using extent of intra year price rise (IPR), coefficient of average seasonal price variation (ASPV) and coefficient of variation (CV) as follows:

$$IPR = \frac{HSPI - LSPI}{LSPI} \times 100$$

$$ASPV = \frac{HSPI - LSPI}{\frac{HSPI + LSPI}{2}} \times 100$$

$$CV = \frac{\hat{\sigma}}{\bar{S}} \times 100$$

Where,
HSPI = Highest seasonal price index.
LSPI = Lowest seasonal price index.
$\hat{\sigma}$ = Standard deviation of the seasonal price indices.
$\bar{S}$ = Arithmetic mean of the seasonal price indices.

Market integration

Cointegration test is used to examine the integration between spatially separated commodity markets. Johansen's cointegration test was carried out as it is considered superior to the methodologies of Hendry and Anderson (1975), Engle and Granger (1987), Goodwin and Schroeder (1991) because this allows the testing of cointegration as a system of equation in one step without any prior assumptions regarding the endogenous and exogenous variables. Furthermore, estimation of a number of cointegration relationships can be carried out simultaneously as it does not imposes any restrictions on the test.

Johansen's maximum likelihood test for cointegration

Unit root in a time-series data is merely indicated by the correlogram but is confirmed by the Augmented Dickey- Fuller test (ADF). The autoregressive formula used in ADF test was:

$$\Delta p_{it} = \alpha_0 + \gamma p_{it-1} + \sum_{j=2}^{n} ß_i \, \Delta p_{it-j+1} + \varepsilon_t$$

Where,
p_{it} is the price in market *i* at the time t, $\Delta p_{it} = (pit - p_{it-1})$ and α_0 is the intercept or drift term. The joint hypothesis for checking the presence of unit root is: H_0: $Y = \alpha_0 = 0$ using φ1statistic. Failure of the rejection of null hypothesis means that the series is non-stationary.

In a cointegrated equation system $\Delta Y_t = \sum_{i-1}^{k-1} r_i \, \Delta Y_{t-1} + \alpha\beta\gamma_{t-k} + \varepsilon_t$, [where, Y_t is the price, ΔY_{t-1} is the first difference operator ($Y_t - Y_{t-1}$) and matrix $\pi = \alpha\beta$ is (n x n) with rank r ($0 \leq r \leq n$)] represents the number of linear independent cointegration relations in the vectors of matrix. The Johansen's method of cointegrated system is a maximum likelihood method with restriction on rank of the matrix $\pi = \alpha\beta$. The rank of π can be determined by λ_{trace} test statistics and is estimated by

$$\lambda_{trace} = -T \sum_{i=y+1}^{n} \ln (1 - \hat{\lambda}_i), \; for r = 0,1,\ldots,n-1$$

Where,
λ_i's are the Eigen values that represent the strength of the correlation between the first difference portion and the error-correction portion.

The following hypotheses were tested, null hypothesis (H_0): rank of π = r and alternate hypothesis (H_1): rank of π> r, where 'r' is the number of cointegrated equations. This test was carried out with the assumption of linear deterministic trend in the original dataset and just the intercept term in the cointegrating equation. The cointegrating equation had only intercept and no trend due to the difference in the wholesale and retail lentil price series while testing for its stationarity, while the original price series followed a trend because the mean and variance was not found to be constant over a period of time *i.e.*, property of non-stationary.

Granger causality test for price transmission

Prior to analysing and establishing that the wholesale and retail markets were co-integrated to some extent, Granger causality test (1969) was conducted to find the order and direction of cointegrating relationships. Whether market p_1 Granger causes market p_2 or vice versa was checked using the following equation:

$$p_{it} = c + \sum_{j=1}^{n} (\phi \; p_{1t-j} + \delta_j \, p_{2t-j}) + \varepsilon_t$$

Another test of granger causality was conducted between the wholesale and retail prices of the ten selected lentil markets under study, to draw inference that whether wholesale prices granger cause the retail prices or vice versa. A simple test of the joint significance of δk was used to check the Granger causality, *i.e.* H_0:$\delta_1 = \delta_2 = \cdots = \delta n = 0$.

RESULTS AND DISCUSSION

A descriptive analysis for the dataset under study was carried out to infer the mean, median, maximum, minimum, standard deviation, kurtosis and skewness of the wholesale and retail markets of Agra, Bhopal, Guwahati, Indore, Jaipur, Kanpur, Kolkata, Lucknow, Patna Varanasi and all India average.

Table 1 shows that the mean value of wholesale prices for lentil ranges between Rs. 5133.38/quintal for Kolkata to Rs. 5962.21/quintal for Guwahati, while the highest value (Rs. 9535.29/quintal) was found in the Lucknow market and lowest value (Rs. 3175/quintal) was observed in the Patna market. All the markets except the Varanasi market was found to be negatively skewed.

The Table 2 describes that the mean value of retail prices for lentil ranges between Rs. 5499.06/quintal (Rs. 54.99/kg) for Jaipur to Rs. 6499.44/quintal (Rs. 64.99/kg) for Lucknow, while the highest value (Rs. 10000/quintal or Rs. 100/kg) was found in the Kanpur market and minimum

Table 1: Descriptive statistics for the wholesale prices in ten major lentil markets of India (n=108).

Markets	Mean	Median	Minimum	Maximum	Standard deviation	Kurtosis	Skewness
Agra	5578.49	5192.00	3954.55	8577.78	1179.84	-0.24	0.86
Bhopal	5198.27	5000.00	3700.00	7978.95	1242.75	-0.87	0.57
Guwahati	**5962.21**	6000.00	3623.81	9137.50	1409.80	-0.53	0.31
Indore	5332.58	5200.00	3507.50	7841.67	1118.09	-0.79	0.25
Jaipur	5134.28	4800.00	3600.00	7557.89	1081.28	-0.71	0.67
Kanpur	5655.97	5237.94	3550.00	8866.67	1448.90	-0.74	0.54
Kolkata	**5133.38**	4861.37	3375.00	8333.33	1198.61	-0.17	0.77
Lucknow	5889.05	5446.35	4194.80	**9535.29**	1295.89	-0.44	0.76
Patna	5159.88	5000.00	**3175.00**	7910.00	1167.23	-0.51	0.33
Varanasi	5925.17	6000.00	3718.18	8223.33	1378.47	-1.15	**-0.12**
All India Average	5833.48	5586.05	3892.77	8391.03	1187.43	-0.68	0.37

Table 2: Descriptive statistics for the retail prices in ten major lentil markets of India (n=108).

Markets	Mean	Median	Minimum	Maximum	Standard deviation	Kurtosis	Skewness
Agra	5845.73	5414.50	4318.00	8978.00	1236.68	-0.34	0.87
Bhopal	5612.24	5521.50	4036.00	8200.00	1260.93	-0.95	0.51
Guwahati	6355.36	6500.00	3918.00	9525.00	1458.39	-0.65	0.20
Indore	5917.40	5608.00	4477.00	8210.00	1015.74	-0.62	0.63
Jaipur	**5499.06**	5235.50	3900.00	7758.00	1058.52	-0.78	0.51
Kanpur	6201.33	5764.50	4000.00	**10000.00**	1561.81	-0.64	0.64
Kolkata	5958.69	5689.00	4200.00	9057.00	1191.12	-0.15	0.77
Lucknow	**6499.44**	6176.50	4632.00	10094.00	1329.50	-0.35	0.67
Patna	5757.21	6000.00	**3465.00**	8300.00	1216.45	-0.78	**-0.09**
Varanasi	6256.52	6500.00	3819.00	8627.00	1442.77	-1.02	**-0.17**
All India Average	6428.01	6256.50	4529.00	9027.00	1228.52	-0.76	0.32

Table 3: Estimates of the selected lentil wholesale markets according to IPR, ASPV and CV.

Wholesale markets	IPR (%)	ASPV (%)	CV (%)
Agra	5.82	5.66	1.78
Bhopal	3.51	3.45	**0.92**
Guwahati	**2.80**	**2.76**	1.06
Indore	5.80	5.64	1.91
Jaipur	7.04	6.80	2.07
Kanpur	6.56	6.35	2.38
Kolkata	**11.92**	**11.25**	3.11
Lucknow	7.20	6.95	2.33
Patna	8.41	8.07	**3.18**
Varanasi	9.20	8.79	2.92
All India Average	3.86	3.79	1.34

value (Rs. 3465/quintal or Rs. 34.65/kg) was observed in the Patna market. All the markets except the Patna and Varanasi markets were found to be negatively skewed.

The perusal of Table 3 discusses that for the wholesale prices of lentil, the intra-year price rise (IPR) observed during 2011-2019 was 2.80 per cent for Guwahati and 11.92 per cent for Kolkata. The values of average seasonal price variation (ASPV) ranged between 2.76 per cent in Guwahati to 11.25 per cent in Kolkata. The coefficient of variation (CV) varied from 0.92 per cent to 3.18 per cent for the markets of Bhopal and Patna, respectively.

The perusal of Table 4 discusses that for the retail prices of lentil, the intra-year price rise (IPR) observed during the last 9 years was found to be 5.17 per cent for Indore and 8.71 per cent for Varanasi, while the all India average values were found to have the lowest IPR of 4.4 per cent only. The values of average seasonal price variation (ASPV) ranged between 5.04 in Indore to 8.34 in Varanasi, while the all India average values were found to be the lowest (4.30 per cent). The coefficient of variation (CV) varied from 1.12 to 4.56 for the markets of Kanpur and Varanasi, respectively while the CV for the all India average values was found to be lowest at 0.97 per cent.

Table 4: Estimates of the selected lentil retail markets according to IPR, ASPV and CV.

Retail markets	IPR	ASPV	CV
Agra	6.35	6.15	2.18
Bhopal	6.29	6.10	1.78
Guwahati	7.22	6.97	1.90
Indore	**5.17**	**5.04**	1.55
Jaipur	6.44	6.24	2.51
Kanpur	5.22	5.09	**1.12**
Kolkata	7.43	7.17	2.04
Lucknow	7.32	7.06	3.24
Patna	8.22	7.89	4.43
Varanasi	**8.71**	**8.34**	**4.56**
All India Average	**4.40**	**4.30**	**0.97**

Table 5: Seasonal Index for the wholesale prices of the 10 selected lentil markets.

Months	Agra	Bhopal	Guwahati	Indore	Jaipur	Kanpur	Kolkata	Lucknow	Patna	Varanasi	All India Average
January	99.90	99.76	**101.38**	98.15	98.32	98.20	99.65	98.83	95.92	99.82	98.78
February	98.86	99.98	100.16	98.15	97.16	96.77	95.69	97.28	95.87	97.69	98.70
March	97.44	99.94	98.62	**96.32**	**96.37**	**96.76**	**94.60**	97.72	**95.14**	95.63	**97.54**
April	**96.98**	**99.20**	**97.75**	98.86	98.32	99.57	98.15	99.99	97.45	**95.21**	98.68
May	102.41	98.48	100.01	101.04	101.49	**103.10**	99.46	98.01	101.73	97.42	99.96
June	101.35	99.66	99.84	100.01	100.94	102.72	99.67	99.95	102.94	100.16	100.87
July	101.46	99.75	100.92	99.80	100.13	101.35	101.87	96.69	**103.14**	102.85	101.12
August	**102.63**	99.75	100.32	99.71	102.14	98.41	**105.88**	101.20	102.93	**103.97**	**101.30**
Spetember	99.92	99.71	100.44	**102.87**	**103.15**	102.30	101.79	**103.65**	102.76	102.83	**101.30**
October	99.77	100.40	100.24	101.90	100.90	101.91	103.28	102.34	102.37	102.24	101.24
November	100.24	**101.94**	101.22	101.91	101.37	101.36	101.18	102.91	101.30	101.40	101.15
December	99.03	101.45	99.09	101.27	99.71	97.55	98.78	101.42	98.45	100.79	99.38

Table 6: Seasonal Index for the retail prices of the 10 selected lentil markets.

Months	Agra	Bhopal	Guwahati	Indore	Jaipur	Kanpur	Kolkata	Lucknow	Patna	Varanasi	All India Average
January	99.57	99.26	101.40	97.95	98.27	99.25	100.84	**96.94**	96.40	99.77	99.27
February	98.33	99.64	98.32	**97.49**	97.15	99.65	98.19	97.23	**96.15**	97.79	99.09
March	96.72	98.76	**94.57**	97.71	**96.99**	**96.81**	**96.35**	97.43	95.29	**95.33**	**97.35**
April	**96.70**	96.91	99.23	99.26	97.55	99.91	98.40	98.50	97.87	95.83	98.17
May	**102.74**	**96.56**	100.79	100.45	98.82	101.70	99.53	99.12	101.57	96.04	99.44
June	100.75	100.22	100.02	99.61	101.40	**101.86**	97.95	99.92	103.12	100.56	100.88
july	102.83	101.74	**101.35**	99.69	100.23	98.83	100.62	98.05	**103.53**	**103.63**	100.71
August	102.40	**102.63**	101.60	99.85	102.83	98.45	103.51	101.20	102.24	103.24	101.45
Spetember	100.80	100.31	100.63	**102.76**	**103.41**	100.95	101.94	103.63	102.28	102.35	101.39
October	99.64	101.21	100.52	102.18	101.59	101.27	101.80	102.99	102.28	102.70	**101.64**
November	100.25	101.63	101.06	101.81	101.84	101.07	100.94	**104.04**	100.75	101.38	101.02
December	99.28	101.14	100.50	101.26	99.91	100.26	99.94	100.96	98.52	101.39	99.61

Since, lentil is a *rabi* crop which is harvested during March- April, it is expected that the seasonal wholesale indices would be higher during the lean season and would be lowest during the harvest season. All the major markets comply by this and therefore it was observed in table 5 that for the all India average, the lowest SI was found during the month of March while the highest was during August- September.

Table 6 discusses the SI followed by the retail prices of lentil during 2011-2019, it was observed that the lowest SI ranged during the months of January and April while the highest values of SI were scattered throughout the year. In case of all India average prices, the lowest SI were observed for the month of march and highest during the month of October. This confirmed the general notion that the seasonal indices (SI) are lowest during the harvest months and highest during lean months.

Tables 7 and 8 shows that the original wholesale and retail time-series data for lentil were non-stationary and non-significant, but the 1st differentiated series were found to be stationary and significant at one per cent level.

Furthermore, Johansen's cointegration test was carried out to check the existence of integration amongst these ten markets under study, the values of which are shown in the Table 9 and 10 for the wholesale and retail markets, respectively. The values have shown that there seems to exist a very high degree of integration in both the wholesale

Table 7: Estimates of Augmented Dickey Fuller (ADF) test for the monthly wholesale prices.

Markets	ADF statistic for testing unit root		Order
	Level series	1st differenced series	
Agra	-1.4980	-4.9095*	I(1)
Bhopal	-1.5495	-4.7725*	I(1)
Guwahati	-1.4192	-4.4928*	I(1)
Indore	-1.3534	-5.2392*	I(1)
Jaipur	-1.4226	-4.5880*	I(1)
Kanpur	-1.1624	-4.2645*	I(1)
Kolkata	-1.4973	-4.6960*	I(1)
Lucknow	-1.5696	-5.2463*	I(1)
Patna	-1.5212	-5.1834*	I(1)
Varanasi	-1.1133	-4.9673*	I(1)
All India Average	-1.1998	-4.3463*	I(1)

Note: *indicates the significance at one per cent level of MacKinnon (1996) one-sided p-values.

Table 8: Estimates of Augmented Dickey Fuller (ADF) test for the monthly retail prices.

Markets	ADF statistic for testing unit root		Order
	Level series	1st differenced series	
Agra	-1.4802	-4.7396*	I(1)
Bhopal	-1.4915	-4.2793*	I(1)
Guwahati	-1.4165	-4.5807*	I(1)
Indore	-1.5551	-5.9971*	I(1)
Jaipur	-1.4164	-4.8064*	I(1)
Kanpur	-1.1356	-3.9064*	I(1)
Kolkata	-1.5298	-4.1998*	I(1)
Lucknow	-1.6732	-6.0393*	I(1)
Patna	-1.5734	-4.7093*	I(1)
Varanasi	-1.0178	-5.0842*	I(1)
All India Average	-1.2174	-4.2031*	I(1)

Note: * indicates the significance at one per cent level of MacKinnon (1996) one-sided p-values.

Table 9: Estimates of Johansen's multiple cointegration test for wholesale prices.

Markets	Lag length (AIC Value)	H_0: rank= r	Eigen value	Trace statistic
Agra		r = 0*	82.4847	355.7513
Bhopal		r ≤ 1*	58.4294	273.2666
Guwahati		r ≤ 2*	49.2138	214.8372
Indore		r ≤ 3*	39.3571	165.6234
Jaipur		r ≤ 4*	33.1251	126.2663
Kanpur	4	r ≤ 5*	26.9579	93.1412
Kolkata		r ≤ 6*	20.8222	66.1833
Lucknow		r ≤ 7*	18.2161	45.3611
Patna		r ≤ 8*	17.0961	27.145
Varanasi		r ≤ 9*	5.8885	10.076
All India Average		r ≤ 10*	4.1875	4.1875

Note: *denotes rejection of the null hypothesis at one per cent level of MacKinnon-Haug-Michelis (1999) probability.

and retail markets for the prices of lentil throughout the period under study.

The Granger causality test was next in line to identify the markets that were integrated with each other either in a bidirectional relationship or unidirectional relationship.

The contents of Table 11 describes the relationship of price transmission between the major lentil markets of India. According to the Department of Agriculture, Cooperation and Welfare of India (Agricoop and Agriwatch), Kanpur, Patna and Indore are considered to be the major markets for lentil. It was found that these markets have unidirectional price relationship with the other markets, i.e. prices at these three markets are granger caused by the prices at Agra and Jaipur, while the prices of Kanpur also granger causes the prices of Indore and Patna. The prices of Lucknow are not influenced by the prices of any other markets but in return it granger causes the wholesale market prices of Agra, Bhopal, Guwahati, Indore, Kanpur, Kolkata and all India average.

Table 10: Estimates of Johansen's multiple cointegration test for retail prices.

Markets	Lag length (AIC Value)	H_0: rank= r	Eigen value	Trace statistic
Agra		r = 0*	68.3038	345.0833
Bhopal		r ≤ 1*	62.1673	276.7794
Guwahati		r ≤ 2*	52.0757	214.6122
Indore		r ≤ 3*	41.6797	162.5365
Jaipur		r ≤ 4*	33.9323	120.8568
Kanpur	4	r ≤ 5*	25.3463	86.9245
Kolkata		r ≤ 6*	19.1761	61.5782
Lucknow		r ≤ 7*	19.0140	42.4021
Patna		r ≤ 8*	12.5675	23.3881
Varanasi		r ≤ 9*	5.5321	10.8206
All India Average		r ≤ 10*	5.2885	5.2885

Note: *denotes rejection of the null hypothesis at one per cent level of MacKinnon-Haug-Michelis (1999) probability.

Table 11: Price transmission between the ten wholesale markets and all India average values by Granger causality test.

Markets	Agra	Bhopal	Guwahati	Indore	Jaipur	Kanpur	Kolkata	Lucknow	Patna	Varanasi	All India Average
Agra		→	→	→	X	→	→	X	→	→	↔
Bhopal	X		X	X	X	X	X	X	X	→	X
Guwahati	X	→		→	X	X	X	X	X	→	→
Indore	X	X	X		X	X	X	X	X	→	→
Jaipur	X	→	→	→		→	→	X	→	→	→
Kanpur	X	→	→	→	X		→	X	→	→	→
Kolkata	X	→	→	→	X	X		X	X	→	→
Lucknow	→	→	→	→	X	→	→		X	X	→
Patna	X	→	→	→	X	X	→	X		→	→
Varanasi	X	X	X	X	X	X	X	X	X		↔
All India Average	↔	X	X	X	X	X	X	X	X	↔	

Note: ↔: Bidirectional, →: Unidirectional and X: No causality.

Table 12: Price transmission between the ten retail markets and all India average values by Granger causality test.

Markets	Agra	Bhopal	Guwahati	Indore	Jaipur	Kanpur	Kolkata	Lucknow	Patna	Varanasi	All India Average
Agra		→	→	X	→	→	→	→	X	↔	↔
Bhopal	X		X	X	X	X	X	X	X	→	→
Guwahati	X	→		X	X	X	X	X	→	→	→
Indore	X	→	X		X	→	→	X	X	→	→
Jaipur	X	→	→	X		→	→	X	X	→	→
Kanpur	X	→	X	X	X		X	X	X	→	→
Kolkata	X	→	→	X	X	X		X	→	→	→
Lucknow	X	→	→	→	→	→	→		X	→	→
Patna	X	→	X	X	X	X	X	X		→	→
Varanasi	↔	X	X	X	X	X	X	X	X		X
All India Average	↔	X	X	X	X	X	X	X	X	→	

Note: ↔: Bidirectional, →: Unidirectional and X: No causality.

Same is the case with the Jaipur market, it is unaffected by the wholesale prices of other markets but granger causes the prices of Bhopal, Guwahati, Indore, Kanpur, Kolkata, Patna, Varanasi and all India average. Bidirectional price movements were only observed between the markets of Agra and all India average and Varanasi and all India average. The market of Varanasi does not granger causes the prices of any other market but in return is influenced by the prices of all the other markets (unidirectional relationship) except Lucknow.

Table 12 discusses the relationship between the ten retail markets of lentil under study. The market of Agra has only bidirectional relationship with the Varanasi and all India average prices. The retail and wholesale markets have more or less the same relationship with the other markets under observation. The prices at the Indore and Lucknow are granger caused by the prices of Lucknow and Agra, respectively.

Another Granger causality test was carried out between the wholesale and retail prices of different markets and it was found that there exists bidirectional relationship within the wholesale and retail prices of Bhopal, Jaipur and Lucknow. The markets of Agra, Indore, Kanpur, Kolkata, Varanasi and all India average had no relationship at all between their wholesale and retail prices of lentil. The retail prices of Guwahati and Patna granger causes the wholesale prices of lentil.

CONCLUSION

The mean value of wholesale prices for lentil ranges between Rs. 5133.38 to Rs. 5962.21 per quintal. The original time-series data for wholesale and retail prices for lentil was found to be non-stationary and non-significant, but it turned out to be stationary in the 1st differentiated series at one per cent level of significance. Johansen's multiple cointegration test has indicated the presence of spatial integration amongst majority of the markets both for the major wholesale and retail markets in India. Majority of the states have shown unidirectional/ no price movements price transmission and a few of them have shown bidirectional relationship. The wholesale markets of Jaipur and Lucknow are not granger caused by the wholesale prices of any other wholesale markets and the wholesale markets and retail markets of Jaipur and Lucknow have bidirectional price relationship amongst each other. This may indicate towards the fact that the domestic prices of lentil are discovered in these two markets of Jaipur and Lucknow but it can be proved only by some more technical investigations, which is beyond the scope of this paper. The erratic rainfall coupled with late sowing during the rabi cropping season of 2019 may negatively influence the production and marketing of lentil, which in turn will influence its procurement and pricing. Apart from the domestic production of lentil, India is also dependent upon the imports from the countries like Canada, Australia, USA, Turkey and Ukraine (Department of Commerce). Reforms in the pricing policy of production, marketing, export-import and procurement facilities are required to bring about stability in the wholesale and retail prices of lentil so that the farmers may receive fair and remunerative prices. This may result in increased production and export with reduced import of lentil in the long run.

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