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Testing market integration and convergence to the law of one price in Indian onions

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Spiraling prices of onions in India undermine the sustainability of current economic growth process and raised the question of price integration among the spatially separated markets. Co-integration test has been used to identify whether onion markets in India share a common linear deterministic trend and the law of one price holds true in view of rising prices in the recent past. The study sourced the wholesale daily prices of major onion markets across the country from January 2010 to March 2011. Augmented Dickey Fuller test statistic has been used to check the presence of a unit root in the time series data. Empirical results indicated the presence of unit root and a strong spatial integration between major markets. The study also confirms the law of one price in Indian onions.

Key words: Co-integration, onion, law of one price.

INTRODUCTION

Onion (*Allium cepa*) is being used as a vegetable and spice for thousands of years by many cultures around the world, and it has immense medicinal and therapeutic value (Sendhil, 2012). It is cultivated across different states in India for domestic consumption and international trade. Among them, Maharashtra accounts for about 40% of India's onion output. Rajasthan is the next major producer followed by Karnataka, Andhra Pradesh and Tamil Nadu. Onion is a commercial crop in India, but the crises of 1998 and 2010 played spoilsport in the economy and the welfare of the producers (Sendhil, 2012). Price surge during the crises led to many economic as well as political implications. The prices have hit the roof across the entire nation and the absence of timely intervention to control them resulted in an explosive situation of prices (Nayyar, 2011). Prices rose by 600% from INR 12 to 18 per kg to INR 60 to 100 per kg during December, 2010 across different markets in the country. Even in the recent past, the wholesale prices hit a two-and-a-half-year high bringing tears in the eyes of millions (Reuters, 2013). Following a 50% increase in the monthly wholesale prices, retail prices increase by cent percent particularly in Indian metros with a wide range of prices across major cities. In comparison to the last year, the

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reported price rise was about 500% in Lasalgoan in Maharashtra, Asia's biggest market. Though supply shock arising from excessive rainfall or drought that spoils the bulbs was a major reason for the spiraling prices, it undermined the sustainability and efficiency of public management in controlling the price of the commodity. The difference in prices that prevailed across onion markets in India raised the question of price integration among the spatially separated markets.

Spatial market integration is a situation in which prices of a commodity in spatially separated markets move together due to arbitrage and the price signals and information are transmitted smoothly across the markets. With the free flow of information in a competitive market, the difference in prices of a product in the two markets would be equal to or less than the transportation cost between them. Empirical studies on market integration of agricultural products typically use bilateral price relationships as an indicator of market integration. This methodology falls under the law of one price (LOOP), which states that if the commodity prices are converted to a common currency, then the particular commodity should be sold at the same price in each country or region.

However, in practice is a very rare case. In case of onions too, there is a great likelihood of market integration and price transmission between markets in India, if the markets are efficient and competitive. In this case, a causal relationship between prices in different spatial markets can be measured (Moodley et al., 2000). Market integration also means that a measurable long-run relationship exists between spatially separated prices for the same product. Thus, even when prices temporarily deviate from each other in the short-run, the differentials should eventually converge in the long-run and the speed of price convergence indicates the degree of market integration. In this context, an attempt has been made with the objective finding the extent of market integration within India and whether the LOOP holds true in the case of onions across different markets in India.

MATERIALS AND METHODS

The study is based on time series data on wholesale daily prices of onion collected from the AGMARKNET portal from January 2010 to March 2011. The data set can be used to analyze the price instability which occurred during 2010 to 2011.

Instability in prices

Instability index was used to examine the extent of variation and risk involved in prices. It was measured by Cuddy-Della Valle Index (Cuddy and Della Valle, 1978; Anuja et al., 2013) which is given as, Cuddy-Della Valle Instability (%) $= CV \times \sqrt{(1-\overline{R}^2)}$. Where, *CV* is the coefficient of variation in per cent, and $\overline{R}^2$ is the coefficient of determination from a time trend regression adjusted to its degrees of freedom.

Market integration and price transmission

Estimation of bivariate correlation coefficients between price changes in different markets has been employed as the most common methodology for testing market integration (Cummings, 1967; Lele, 1967, 1971). But it indicates the integration of markets only in the short-run. Economic theory often suggests that certain pairs of economic variables should be linked by a long-run equilibrium relationship. Despite price series move away from the equilibrium point for a while, economic forces may be expected to act so as to restore equilibrium. Granger (1981) proposed the concept of co-integration which states that even though several price time series have unit roots, a linear combination of them would not have a unit root. Since the introduction of co-integration techniques by Engle and Granger (1987), Johansen (1988, 1991, 1994, 1995), Johansen and Juselius (1990), and Goodwin and Schroeder (1991) researchers have applied it on non-stationary data. The Engle and Granger method is basically a bi-variate approach that accommodates relationships only between two price series.

As a result, this shortcoming does not lend itself well to analyzing multivariate systems that characterize, for example, markets with many sellers and buyers. In addition, the results are sensitive to which price series is used to normalize the other. Hypothesis testing on the estimated co-integration vector is also not possible under this approach. The Johansen method is preferred over the Engle and Granger approach and has proven to be popular in the recent literature on market integration (Kumar and Sharma, 2003). Before testing for co-integration, the time series has to be checked for its stationary property. The stationarity properties and the exhibition of unit roots in the time series are substantiated by performing the Augmented Dickey-Fuller (ADF) test. This test is conducted on the variables in level (original price series) and first differences. Price series co-integration arises when the variables are integrated of the same order against the unit root test which identifies the variables that are integrated of order one, or I (1). In a co-integrated equation system:

$$\Delta Y_t = \sum_{i=1}^{k-1} \Pi_i \Delta Y_{t-i} + \alpha\beta' Y_{t-k} + \varepsilon_t$$

where Y_t is the price time series, Δ is the first difference operator ($Y_t - Y_{t-1}$) and matrix $\Pi = \alpha\beta'$ is (n x n) with rank r ($0 \le r \le n$), which is the number of linear independent co-integration relations in the vector space of a matrix. The Johansen's method of co-integrated system is a restricted maximum likelihood method with rank restriction on matrix $\Pi = \alpha\beta'$ (Anuja et al., 2013). The rank of Π can be determined by using λ_{trace} or λ_{max} test statistics. Integration between two markets can be checked in a similar fashion through bi-variate Johansen's test. Since the test is very sensitive to price lag, the choice of lag length should be determined well. After testing for co-integration, the residuals show the deviation from equilibrium and this equilibrium error in the long-run tends to zero. Vector error-correction model (VECM) can be used to capture the deviations from the long-run equilibrium (Brosig et al., 2011). The model is represented as:

$$\Delta A_t = \alpha_0 + \alpha_1 \Delta B_t + \alpha_2 u_{t-1} + \varepsilon_t$$

Where, A_t is the price of market 'A', B_t is the price of market 'B' and u_t is the co-integration vector. The coefficient (α_2) of the error-correction term (u_{t-1}) indicates the speed at which the series returns to equilibrium. If it is less than zero, the series converge to long-run equilibrium and if it is positive and zero, the series diverges from equilibrium.

Table 1. Selected onion markets from different states/union territory.

S/No.	State / Union Territory	Selected market	Basis for selection
1.	Karnataka	Bangalore	Production
2.	Tamil Nadu	Chennai	Consumption
3.	Delhi	Delhi	Wholesale market
4.	Rajasthan	Jaipur	Consumption
5.	West Bengal	Kolkata	Consumption
6.	Maharashtra	Lasalgaon	Production (Asia's biggest market)
7.	Maharashtra	Mumbai	Production
8.	Maharashtra	Nasik	Production

Law of one price (LOOP) analysis

LOOP analysis tests the hypothesis on the coefficients of both α and β using likelihood ratio tests as outlined in Johansen and Juselius (1990). To test for the LOOP, restrictions can be placed and tested on the parameters in the β matrix. In the case of a bivariate system where two price series are examined, the rank of $\pi = \alpha\beta'$ is equal to one, and the dimensions of α and β matrices are 2 x 1. LOOP is tested by imposing the restriction $\beta' = (1, -1)'$. Since the matrix β contains long-run parameters in the system of equations, the test can be considered as a valid one for LOOP in the long-run.

RESULTS AND DISCUSSION

Price behavior of onions in major Indian markets

The price behaviour in major onion markets in India, selected on the basis of production and consumption criteria, (Table 1) was studied with respect to the direction of movement in prices. The price behavior in different markets across the country is depicted in Figure 1. The figure shows the symmetric pattern in the movement of prices in all the markets of the country with peak prices during the months of December (2010) and January (2011) confirming a similar pattern identified by Reddy et al. (2012) in metro cities of India. The plausible reason was supply shock due to unexpected rainfall during the months of September – October which affected the production exhaustively in the major onion growing belts of the country.

Chennai being a region of high consumption of onions with little production, the commodity has to be transported from different parts of the country. Hence, the maximum wholesale price of INR7000/quintal (Table 2) prevailed there which is due to the transportation cost. As expected, the minimum price prevailed in Lasalgaon (INR361/quintal), the Asia's biggest onion market. The average price during the study period was high in Chennai and low in the case of Nasik. As expected, standard deviation and variance was higher in the case of Chennai market. All the markets exhibited a positively skewed distribution. Excluding Chennai and Jaipur, the rest of the markets showed a leptokurtic (slim or long tailed) pattern of probability distribution.

Onion markets integration and price transmission

Market integration is the co-movements or long-run relationship between the spatial prices. The selected markets are tested for co-integration analysis using Johansen's approach. Before co-integration, correlation between different onion markets was carried out to know the short-run integration (Table 3). Correlation analysis revealed a positive co-movement between the onion price series, *apriori*. The results indicated a high degree of significant positive correlation between all the major onion markets that are spatially separated. Before testing for co-integration relationship between different onion market prices, it is mandatory to check the order of integration of the level variables. Hence, for each non-stationary variables, unit root test at their levels as well as first differences were conducted for each market after converting the original series to natural logarithms (Table 4). The results indicated the presence of a unit root at their levels that is, non-stationarity of each market price time series. However, all the non-stationary variables are found to be stationary at their first differences, and therefore, are integrated of order one, I(1) corroborating with the findings of Sidhu et al. (2010) that employed the Augmented Dickey-Fuller (ADF) statistic while studying the integration of wholesale market prices for onions within Punjab state of India. This conformation that each level series is I(1) allows to proceed with the Johansen's co-integration test (Table 5).

The co-integration test revealed the Eigen value and the trace statistic for each market. The test rejected the null hypothesis of no co-integration relationship between the onion market ($r = 0$ to $r \leq 4$) at 5% level of probability indicating the presence of five co-integration vectors between those markets in the long-run (Table 5). The purpose of this analysis was to know whether the onion markets in India are integrated, and thereby price transmission takes place. These findings are also supported by Sidhu et al. (2010) despite their use of Augmented Engle and Granger co-integration test.

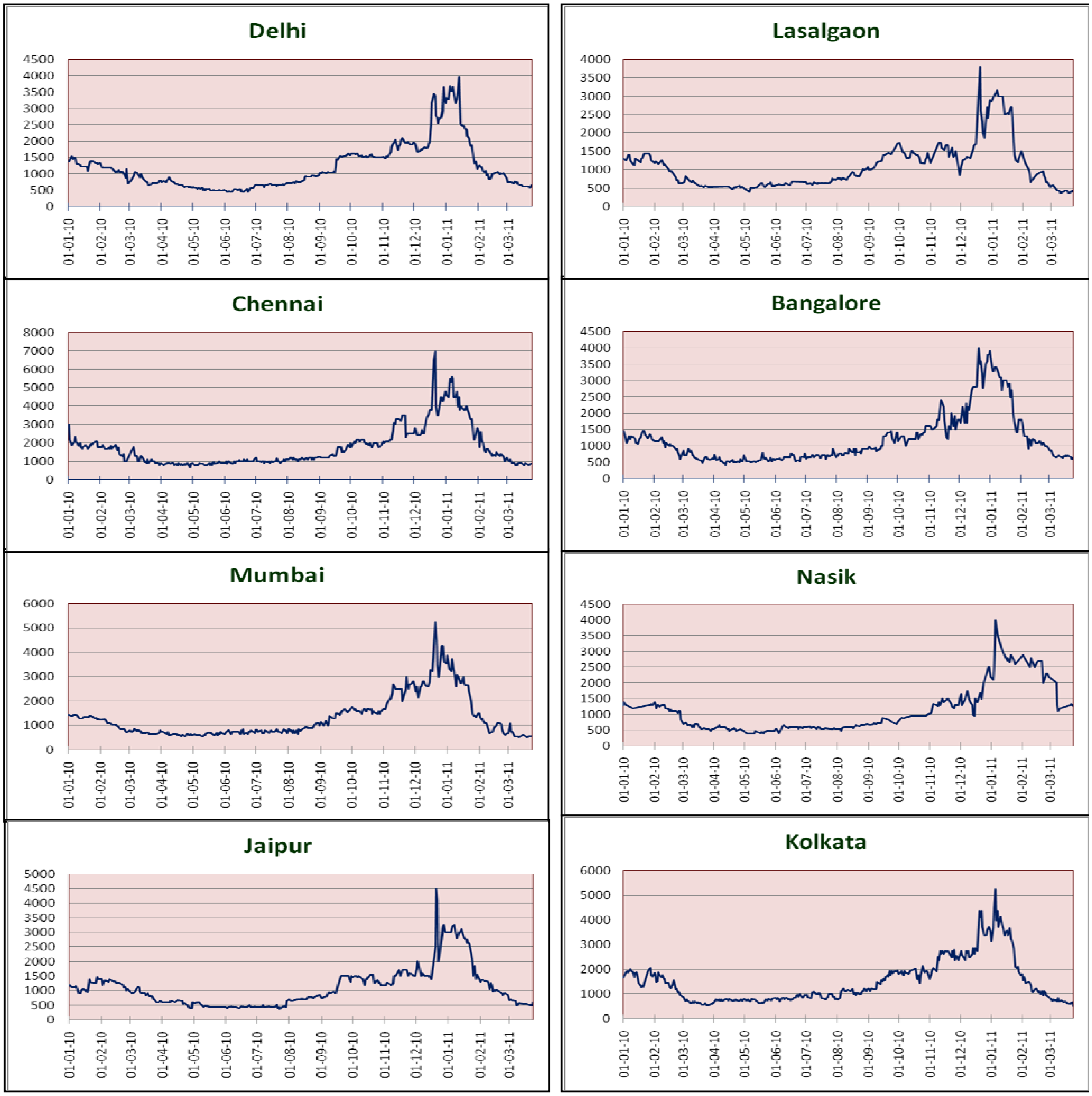

Figure 1. Price behaviour (INR/quintal) of onion in different markets of India.

Yogisha et al. (2006) employed a distributed lag model and found that onion markets in Kolar district of Karnataka were highly integrated attributing to the timely available information on prices. Reddy et al. (2012) also confirmed a high degree of price integration for a majority of the onion markets and they indicated that *inter alia,* 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 and the speed of flow can be estimated through the VECM. For this, bi-variate (2 markets) co-integration analysis has been done and the integrated markets were tested with error-correction mechanism. The results of the VECM indicated that most of the estimated coefficients were negative for market 1 and positive for market 2 (Table 6). This indicated that those series with positive coefficients diverge from equilibrium and negative coefficients converge to equilibrium in the short-run. However, further changes in the subsequent periods help the price series to achieve equilibrium in the long-run. The vector error-correction coefficient was estimated at -0.1467 for market 1

Table 2. Summary statistics of onion market prices.

Particulars	Bangalore	Chennai	Delhi	Jaipur	Kolkata	Lasalgaon	Mumbai	Nasik
Observations	448	448	448	448	448	448	448	448
Maximum (INR/quintal)	4000	7000	3975	4500	5250	3800	5250	4000
Minimum (INR/quintal)	425	700	450	370	500	361	525	375
Range (INR/quintal)	3575	6300	3525	4130	4750	3439	4725	3625
Mean (INR/quintal)	1185.30	1724.93	1203.97	1092.57	1501.42	1064.95	1318.87	1044.60
Standard deviation	758.16	1059.75	709.58	681.41	893.19	610.24	852.99	613.20
Variance	574809	1123063	503504	464316	797790	372389	727595	376018
Skewness	1.74	1.78	1.60	1.71	1.33	1.58	1.60	1.59
Kurtosis	2.54	3.36	2.58	3.53	1.39	2.69	2.30	2.70
Instability (%)	56.24	55.97	53.47	57.47	53.90	53.57	58.24	54.50

Table 3. Price correlation between major onion markets in India.

Market (n = 448)	Bangalore	Chennai	Delhi	Jaipur	Kolkata	Lasalgaon	Mumbai	Nasik
Bangalore	1	0.95*	0.95*	0.92*	0.94*	0.92*	0.95*	0.94*
Chennai	0.95*	1	0.95*	0.92*	0.95*	0.93*	0.94*	0.93*
Delhi	0.95*	0.95*	1	0.93*	0.95*	0.94*	0.94*	0.93*
Jaipur	0.92*	0.92*	0.93*	1	0.92*	0.92*	0.89*	0.92*
Kolkata	0.94*	0.95*	0.95*	0.92*	1	0.94*	0.95*	0.94*
Lasalgaon	0.92*	0.93*	0.94*	0.92*	0.94*	1	0.89*	0.93*
Mumbai	0.95*	0.94*	0.94*	0.89*	0.95*	0.89*	1	0.93*
Nasik	0.94*	0.93*	0.93*	0.92*	0.94*	0.93*	0.93*	1

* indicates the significance of Spearman's correlation coefficient at one per cent level of probability.

Table 4. Estimates of ADF test for unit root and lag length based on Akaike Information Criterion (AIC).

Market	Level series		1st differenced series	
	ADF statistic	AIC lag length	ADF statistic	AIC lag length
Bangalore	-1.64	13	-3.15*	17
Chennai	-1.39	5	-12.95*	4
Delhi	-2.14	15	-4.20*	14
Jaipur	-1.44	4	-16.47*	3
Kolkata	-2.08	16	-3.78*	16
Lasalgaon	-2.67	17	-9.05*	7
Mumbai	-1.83	15	-4.05*	14
Nasik	-2.62	17	-3.84*	17

* indicate significance at one per cent level of MacKinnon (1996) one-sided p-values.

(Bangalore) and 0.1761 for market 2 (Chennai). This indicated the speed at which Chennai and Bangalore prices adjust towards the equilibrium in case of any price shocks in other markets. In other words, the coefficient measures the ability of the prices to incorporate shocks or price news available in the market. In this case, Chennai and Bangalore markets absorb 17.61 and 14.67% respectively to bring about the equilibrium in prices. The information flow is more in Chennai market as evident by the magnitude of the coefficient (0.1761). Hence Chennai is more efficient than the Bangalore market in terms of reaction to news on price. Similar kind of interpretation can be done for rest of the markets.

Law of one price (LOOP)

Trace tests showed one co-integrating vector for all the selected markets, the number of common stochastic trends turned out to be one for these markets (Table 7).

Table 5. Estimates of Johansen's multivariate co-integration test.

Data period	: 6/01/2010 to 24/03/2011			
Included observations	: 443 after adjustments			
Trend assumption	: Linear deterministic trend			
Lag length	: 1 to 4			
Markets: Lasalgaon, Mumbai, Delhi, Chennai, Jaipur, Kolkata, Nasik and Bangalore				
Null Hypothesis	**Eigen Value**	**Trace Statistic**	**Critical Value at 5 %**	**Significance****
r = 0*	0.1418	250.5196	159.5297	0.0000
r ≤ 1*	0.1248	182.7667	125.6154	0.0000
r ≤ 2*	0.0918	123.7211	95.7537	0.0002
r ≤ 3*	0.0708	81.0821	69.8189	0.0048
r ≤ 4*	0.0611	48.5636	47.8561	0.0428
r ≤ 5	0.0230	20.6124	29.7971	0.3822
r ≤ 6	0.0178	10.3184	15.4947	0.2570
r ≤ 7	0.0053	2.3651	3.8415	0.1241

Trace test indicates five co-integrating equation(s) at the 0.05 level, * denotes rejection of the hypothesis at the 0.05 level and ** shows the MacKinnon-Haug-Michelis (1999) probability values.

Table 6. Estimates of Johansen's bivariate co-integration analysis and error correction model.

Markets	Null hypothesis H_0: rank= r	Eigen Value	Trace Statistic	Error-correction estimates		Log Likelihood
				Market 1	Market 2	
Bangalore and Chennai	r = 0*	0.1284	62.81	-0.1467	0.1761	846.75
	r ≤ 1	0.0034	1.54	(0.0322)	(0.0308)	
Bangalore and Delhi	r = 0*	0.0671	31.86	-0.1058	0.0547	1023.70
	r ≤ 1	0.0019	0.87	(0.0260)	(0.0162)	
Bangalore and Jaipur	r = 0*	0.0645	31.72	-0.0237	0.0935	845.51
	r ≤ 1	0.0045	1.99	(0.0204)	(0.0186)	
Bangalore and Kolkata	r = 0*	0.0744	35.00	-0.1286	0.0589	903.85
	r ≤ 1	0.0012	0.53	(0.0262)	(0.0217)	
Bangalore and Lasalgaon	r = 0*	0.0554	26.84	-0.0748	0.0601	869.87
	r ≤ 1	0.0032	1.44	(0.0222)	(0.0198)	
Bangalore and Mumbai	r = 0*	0.0884	42.58	-0.1623	0.0403	889.69
	r ≤ 1	0.0030	1.32	(0.0271)	(0.0241)	
Bangalore and Nasik	r = 0*	0.0816	39.52	-0.1059	0.0878	905.98
	r ≤ 1	0.0035	1.56	(0.0260)	(0.0211)	
Chennai and Delhi	r = 0*	0.0628	29.87	-0.0372	0.1131	1047.68
	r ≤ 1	0.0021	0.95	(0.0170)	(0.0260)	
Chennai and Jaipur	r = 0*	0.0643	31.67	-0.0264	0.1042	869.46
	r ≤ 1	0.0045	2.02	(0.0223)	(0.0207)	
Chennai and Kolkata	r = 0*	0.0873	41.29	-0.1577	0.0589	926.13
	r ≤ 1	0.0013	0.57	(0.0282)	(0.0245)	

Table 6. Contd.

Chennai and Lasalgaon	r = 0*	0.0668	32.37	-0.1050	0.0568	895.30
	r ≤ 1	0.0034	1.51	(0.0245)	(0.0231)	
Chennai and Mumbai	r = 0*	0.1163	56.58	-0.2010	0.0263	913.85
	r ≤ 1	0.0032	1.44	(0.0279)	(0.0262)	
Chennai and Nasik	r = 0*	0.1040	50.48	-0.1502	0.0810	929.34
	r ≤ 1	0.0033	1.49	(0.0266)	(0.0229)	
Delhi and Jaipur	r = 0*	0.1295	63.16	0.019416	0.2086	1071.86
	r ≤ 1	0.0029	1.31	(0.0185)	(0.0258)	
Delhi and Kolkata	r = 0*	0.0376	17.53	-0.0417	0.0573	1110.60
	r ≤ 1	0.0010	0.44	(0.0152)	(0.0200)	
Delhi and Lasalgaon	r = 0*	0.0564	26.73	-0.0517	0.0589	1079.69
	r ≤ 1	0.0019	0.84	(0.0142)	(0.0204)	
Delhi and Mumbai	r = 0*	0.0730	34.78	-0.0856	0.0422	1096.76
	r ≤ 1	0.0022	0.99	(0.0163)	(0.0232)	
Delhi and Nasik	r = 0*	0.0692	33.07	-0.0676	0.0653	1113.10
	r ≤ 1	0.0024	1.08	(0.0156)	(0.0208)	
Jaipur and Kolkata	r = 0*	0.0459	21.91	-0.0764	-0.0051	933.67
	r ≤ 1	0.0021	0.95	(0.0167)	(0.0149)	
Jaipur and Lasalgaon	r = 0*	0.0466	23.24	-0.0745	0.0007	917.81
	r ≤ 1	0.0044	1.98	(0.0163)	(0.0166)	
Jaipur and Mumbai	r = 0*	0.0573	28.72	-0.0838	-0.0130	915.30
	r ≤ 1	0.0053	2.39	(0.0162)	(0.0153)	
Jaipur and Nasik	r = 0*	0.0531	26.98	-0.0808	0.0126	935.57
	r ≤ 1	0.0059	2.65	(0.0174)	(0.0155)	
Kolkata and Lasalgaon	r = 0*	0.0650	30.62	-0.0680	0.0752	977.34
	r ≤ 1	0.0014	0.64	(0.0207)	(0.0228)	
Kolkata and Mumbai	r = 0*	0.0907	43.26	-0.1354	0.0699	985.05
	r ≤ 1	0.0019	0.83	(0.0233)	(0.0250)	
Kolkata and Nasik	r = 0*	0.0775	36.79	-0.0867	0.0934	998.14
	r ≤ 1	0.0018	0.81	(0.0227)	(0.0229)	
Lasalgaon and Mumbai	r = 0*	0.0483	23.61	-0.0882	0.0291	971.87
	r ≤ 1	0.0035	1.55	(0.0232)	(0.0218)	
Lasalgaon and Nasik	r = 0*	0.1057	51.56	-0.1459	0.1225	989.30
	r ≤ 1	0.0039	1.74	(0.0310)	(0.0273)	

Table 6. Contd.

Mumbai and Nasik	r = 0*	0.0683	32.92	-0.0510	0.0976	979.78
	r ≤ 1	0.0030	1.36	(0.0227)	(0.0212)	

* denotes rejection of the null hypothesis at 5 % level of MacKinnon-Haug-Michelis (1999) probability values. The critical value for rejecting the null hypothesis at 5% , H_0: r=0 is 15.49 and r ≤ 1is 3.81. Figures in parenthesis indicate the standard errors.

Table 7. LOOP analysis for onion markets.

Markets	Null hypothesis H_0: rank= r	Number of co-integrated vectors	Number of stochastic trends	LOOP
Bangalore and Chennai	r = 0*	1	1	Yes
	r ≤ 1	1	1	
Bangalore and Delhi	r = 0*	1	1	Yes
	r ≤ 1	1	1	
Bangalore and Jaipur	r = 0*	1	1	Yes
	r ≤ 1	1	1	
Bangalore and Kolkata	r = 0*	1	1	Yes
	r ≤ 1	1	1	
Bangalore and Lasalgaon	r = 0*	1	1	Yes
	r ≤ 1	1	1	
Bangalore and Mumbai	r = 0*	1	1	Yes
	r ≤ 1	1	1	
Bangalore and Nasik	r = 0*	1	1	Yes
	r ≤ 1	1	1	
Chennai and Delhi	r = 0*	1	1	Yes
	r ≤ 1	1	1	
Chennai and Jaipur	r = 0*	1	1	Yes
	r ≤ 1	1	1	
Chennai and Kolkata	r = 0*	1	1	Yes
	r ≤ 1	1	1	
Chennai and Lasalgaon	r = 0*	1	1	Yes
	r ≤ 1	1	1	
Chennai and Mumbai	r = 0*	1	1	Yes
	r ≤ 1	1	1	
Chennai and Nasik	r = 0*	1	1	Yes
	r ≤ 1	1	1	
Delhi and Jaipur	r = 0*	1	1	Yes
	r ≤ 1	1	1	

Table 7. Contd.

Delhi and Kolkata	r = 0*	1	1	Yes
	r ≤ 1	1	1	
Delhi and Lasalgaon	r = 0*	1	1	Yes
	r ≤ 1	1	1	
Delhi and Mumbai	r = 0*	1	1	Yes
	r ≤ 1	1	1	
Delhi and Nasik	r = 0*	1	1	Yes
	r ≤ 1	1	1	

The number of common stochastic trends was determined by subtracting the number of co-integrating vectors from the dimension of the impact matrix given by the number of variables (*n*) included in the co-integration test. The findings of *n* - 1 co-integrating vectors implied that all the prices contain the same stochastic trend and so they are co-integrated in pairs. This suggested that the LOOP holds true for the onion markets across India.

Conclusions

The study of past price behavior and price co-movement in major onion markets in India conclusively support the existence of an integrated market in the commodity. Several conclusions follow from this result. Price transmission occurs between geographically separated markets in onion due to market information flow through diverse channels.

However, the speed of convergence of onion prices to equilibrium depends on the speed of information dissemination, the government's control over the commodity, time-to-time regulations and policy harmonisation within the regions of the country. One of the reasons for market integration is the efficient functioning of markets itself which is clearly evident from the realisation of law of one price. Therefore, commodity based analysis on marketing integration and market research are better suited to understand the price behaviour of different agricultural commodities. This kind of studies is equally important as they provide policy makers with better information on expected market behaviour which will enable the decision making process on resource allocation. More resources should be allocated to those markets having a higher degree of integration and market efficiency. This will help in enhancing the overall efficiency of the marketing function in agricultural commodities and reduce market distortions.

Conflict of Interest

The authors have not declared any conflict of interest.

REFERENCES

Anuja AR, Amit K, Jha GK, Rakesh K (2013). Price dynamics and market integration of natural rubber under major trade regimes of India and abroad. Ind. J. Agric. Sci. 83(5):555-560.

Brosig S, Glauben T, Gotz L, Weitzel E, Bayaner A (2011). The Turkish wheat market: Spatial price transmission and the impact of transaction costs. Agribuss 27(2):147-161. http://dx.doi.org/10.1002/agr.20257

Cuddy JDA, Della-Valle PA (1978). Measuring the instability of time series data. Oxf. Bull. Eco. Stat. 40(1):79-85. http://dx.doi.org/10.1111/j.1468-0084.1978.mp40001006.x

Cummings RW (1967). Pricing Efficiency in the Indian Wheat Market. Impex India, New Delhi.

Engle RF, Granger CWJ (1987). Cointegration and error-correction: Representation, estimation and testing. Econometrica 55:251-276. http://dx.doi.org/10.2307/1913236

Goodwin BK, Schroeder TC (1991). Cointegration tests and spatial price linkages in regional cattle markets. Am. J. Agric. Econ. 73:452-64. http://dx.doi.org/10.2307/1242730

Granger C (1981). Some properties of time series data and their use in econometric model specification. J. Econ. 16:121-130. http://dx.doi.org/10.1016/0304-4076(81)90079-8

Johansen S (1988). Statistical analysis of cointegration vectors. J. Eco. Dyn. Control 12:231-254. http://dx.doi.org/10.1016/0165-1889(88)90041-3

Johansen S (1991). Estimation and hypothesis testing of cointegration vectors in Gaussian vectors auto regression models. Econometrica 59:51-80. http://dx.doi.org/10.2307/2938278

Johansen S (1994). The role of the constant and linear terms in cointegration analysis of nonstationary variables. Econom. Rev. 13:205-229. http://dx.doi.org/10.1080/07474939408800284

Johansen S (1995). Likelihood-based Interference in Cointegrated Vector Autoregressive Models. Oxford: Oxford University Press. http://dx.doi.org/10.1093/0198774508.001.0001

Johansen S, Juselius K (1990). Maximum likelihood estimation and inference on cointegration with applications to the demand for money. Oxf. Bultn. Econ. Stat. 52(2):169-210. http://dx.doi.org/10.1111/j.1468-0084.1990.mp52002003.x

Kumar P, Sharma RK (2003). Spatial price integration and price efficiency at farm level: A study of paddy in Haryana. Ind. J. Agric. Econ. 58(2):201-217.

Lele UJ (1967). Market integration: A study of sorghum prices in western India. J. Farm. Econ. 49:147-159. http://dx.doi.org/10.2307/1237074

Lele UJ (1971). Food Grain Marketing in India: Private Performance and Public Policy. Cornell University Press, Ithaca, New York. PMCid:PMC2008758

Moodley D, Kerr WA, Gordon DV (2000). Has the Canada - US trade agreement fostered price integration?. Rev Weltwirtschaftliches Arch. 136:334-354. http://dx.doi.org/10.1007/BF02707691

Nayyar D (2011). The great onion coverup - Special report on onion. India Today 1:29-33.

Reddy BS, Chandrashekhar SM, Dikshit AK, Manohar NS (2012). Price trend and integration of wholesale markets for onion in metro cities of India. J. Econ. Sust. Dev. 3(7):120-129.

Reuters (2013). Wholesale onion price jumps 5-times; To push up retail rates. NDTV Profit published on July 17, 2013. Retrieved on 20.07.2013 from http://profit.ndtv.com/news/economy/article-wholesale-onion-price-jumps-5-times-to-push-up-retail-rates-324600.

Sendhil R (2012). Production and export performance of onions – An exploratory study. Agric. Sitn. Ind. 69(7):355-362.

Sidhu RS, Sanjay K, Kamal V, Parminder S (2010). Supply chain analysis of onion and cauliflower in Punjab. Agric. Econ. Res. Rev. 23:445-453.

Yogisha GM, Karnool NN, Vijayakumar HS, Basavaraja H (2006). Market integration for major agricultural commodities in Kolar district, Karnataka. J. Agric. Sci. 19(4):857-861.