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Market Integration and Price Transmission in Major Onion Markets of India

Mumtaz Ahmed* and Naresh Singla

Centre for Economic Studies, Central University of Punjab, Bathinda, Punjab, India

Corresponding author: mumtaza61@gmail.com

ABSTRACT

Market integration and prices in horticultural crops such as onion play an important role in determining the production decisions of the farmers and diversification to high value crops. In this context, the study explores market integration and price transmission in selected onion markets using Johansen cointegration, Granger causality and impulse response function. The outcomes of the study strongly buttressed to the co-integration and interdependence of onion markets in India. The impulse response function supported that except Mumbai and Kozhikode, all other selected markets are responded well to standard deviation shock given to any of the markets. One of the possible reasons might be that Mumbai is the largest supplier of onion and Kozhikode is geographically dispersed and is a sea port, where foreign produce may be arriving in a larger quantity. The overall regional markets of onion are strongly cointegrated that allows the private traders and restricts the role of government intervention.

Keywords: Cointegration, onion prices, markets integration, agricultural markets

The agriculture sector in India has witnessed a sluggish growth during the last decade and so. However, one of its sub-sectors, which has really performed well during this period, is horticulture sector. Horticulture sector witnessed an average annual growth of 5% as against only 3.91% for agriculture sector as a whole during the 2010-11 to 2014-15. The area under horticulture accounts for only 8.5% of the cropped area, but it contributes about 30% in value of output in agriculture (GOI, 2014). Among all the commodities in the horticulture basket, onion is a major vegetable crop in India, which is grown over an area of 1.2 million hectare with a production of 19.4 million tonne (GOI, 2016). Prices in horticultural crops play an important role in distributing the resources efficiently and signaling shortages and surpluses, which help the farmers to respond to dynamic market conditions (Haji and Gelaw, 2011), Occasionally, onion prices remain quite volatile in domestic markets. Since the demand for onion is inelastic, a small change in its supply leads to high price volatility in the domestic markets. In India, production of onion is largely localized in Maharashtra, which accounts for about 30% of the total onion production (GOI, 2016). Thus, the supply shock in such large onion producing markets due to either excess rainfall or drought is quickly transmitted to the other markets of the country (Sendhil, *et al.,* 2014; Singla, 2015).

Market integration shows the extent to which prices in different markets move together (Barret, 2001). It is considered as pre-condition for affective marketing reforms to take place. The high degree of market integration indicates the competitiveness of the markets. The well-integrated market provides the ways for the farmers to specialize according to comparative advantage. The markets that are not integrated presents inaccurate picture about price information, which may distort production decisions of the producers and contribute to inefficiencies in agricultural markets, harm the ultimate consumers and lead to low production and sluggish growth (Mukhtar and Javed, 2008). Market integration also plays a vital role in determining pattern and pace of diversification towards the high value crops (Sidhu *et al.*, 2010). Further, it also becomes difficult to comprehend trade policy as several obstructions such as stocking limits, inefficient markets, weak supply chains and trade cartels often restrict the efficient functioning of the markets (Chengappa *et al.*, 2012). In India, there exist several studies, which have analyzed market integration in food grain crops such as wheat, rice etc. (Ghosh, 2003; Ghosh, 2011; Ghoshray and Ghosh, 2011; Acharya, *et al.*, 2012; Ghosh, 2012; Sekhar, 2012). The existing literature on market integration in horticultural crops is quite scanty (Basu, 2006; Beag and Singla, 2014; Wani, *et al.*, 2015), while no such studies except Sendhil *et al.*, (2014) and Reddy *et al.* (2012) exist in onion, which analyze market integration and price transmission in spatially separated markets. Both the studies were conducted in pre-2011 period during which the prices of onion were generally stable and as such impact of price shocks in one market was not visible in other markets. The formulation of valid study on the market integration in onion has potential application for the development of agricultural markets. Against this backdrop, the existing study analyses market integration in onion and its price transmission analysis in selected markets of India.

DATA AND METHODOLOGY

The study has culled monthly wholesale price (₹/100 kg) data for six major onion markets namely, Hyderabad, Kanpur, Kozhikode, Lasalgaon, Lucknow and Mumbai for the period of January 2006 to December 2014 in logarithmic form. All the relevant data have been collected from Directorate of Economics and Statistics, Department of Agriculture and Cooperation. The markets are selected on the basis of their location in highest production areas of onion (Lasalgaon and Mumbai); markets with no nearby production, but only consuming market (Kozhikode); markets with both high production and consumption (Kanpur and Lucknow); while one centrally located market (Hyderabad) was also selected to comprehend the price transmission and market integration among them.

Techniques and Tools Used

Unit root test

The regression analysis of non-stationary time series produces spurious results, which can be misleading (Ghafoor, *et al.*, 2009). The most appropriate method to deal with non-stationary time series for estimating long-run equilibrium relationships is cointegration, which necessitates that time series should be integrated of the same order. Augmented Dickey-Fuller (ADF) and Phillips-Perron test (PP) is used to verify the order of integration for each individual series. The ADF test, tests the null hypothesis of unit root for each individual time series. The rejection of the null hypothesis indicates that the series is non-stationary and *vice-versa* (Dickey and Fuller, 1981). The number of the appropriate lag for ADF is chosen for the absence of serial correlation using Akaike Information Criterion (AIC). The ADF test is based on the Ordinary Least Squares (OLS) method and requires to estimate the following model.

$$\Delta \ln P_t = \alpha_0 + \delta_1 t + \gamma \ln P_{t-1} + \sum_{j=i}^{q} \vartheta_j \Delta \ln P_{t-j} + \varepsilon_t$$

Where, P the price in each market, Δ is the difference parameters (i.e., $\Delta P_1 = P_t - P_{t-1}$, $P_{t-1} = P_{t-1} - P_{t-2}$ and $P_{n-1} = P_{n-1} - P_{n-2}$) and so on, α_0 is the constant or drift, t is the time or trend variable, q is the number of lags length and ε_t is a pure white noise error term.

Phillips and Perron test

The Dickey and Fuller test assumes that the error term is uncorrelated, identically and independently distributed (i. i. d). Phillip and Perron (1988) modified Dickey-Fuller test and developed a new test popularly known as PP test based on nonparametric statistical method free from the assumption of uncorrelated, identically and independently distribution of error term (Jena, 2016). The asymptotic distribution of the Phillips and Perron test (PP) is same as that of ADF test. The PP test developed more comprehensive theory and had greater power to reject the null hypothesis of the unit root.

Johansen Cointegration

The maximum likelihood (ML) method of cointegration is applied to check long-run wholesale prices relation between the selected markets of India (Johansen, 1988; Johansen and Juselius, 1990). The starting point of the ML method is vector autoregressive model of order (k) and may be written as:

$$P_t = \sum_{i=1}^{k} A_i P_{t-1} + \mu + \beta_t + \varepsilon_t;\ (t = 1,2,3\ldots\ldots T)$$

Where, denotes the (n*1) vector of non-stationary or integrated at order one, i.e., I(1) prices series. The procedure for estimating the cointegration vectors for is based on the error correction model (ECM) representation given by:

$$\Delta P_t = \mu + \Pi P_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta P_{t-i} + \beta \mu_t + \varepsilon_t$$

Where, $\Gamma_i = -(I - \Pi_i - \ldots\ldots, T);\ i = 1,2,\ldots\ldots K-1;$

$$\Pi = -(I - \Pi_i - \ldots\ldots\ldots \Pi_k)$$

Both Γ_i and Π_i are the n*n matrixes of the coefficient conveying the short and long run information respectively, μ is a constant term, t is a trend, and ε_t is the n-dimensional vector of the residuals that is identical and independent distributed. The vector ΔP_t is stationary P_t is integrated at order one I(1) which will make unbalance relation as long as Π matrix has a full rank of k. In this respect, the equation can be solved by inversing the matrix Π^{-1} for P_t and as a linear combination of stationary variable (Kirchgässner, *et al.,* 2012). The stationary linear combination of the P_t determines by the rank of Π matrix. If the rank r of the matrix Π r=0 the matrix is the null and the series underlying is stationary. If the rank of the matrix Π is such that 0 < rank of (Π) = r < n then there are n × r cointegrating vectors. The central point of the Johansen's procedure is simply to decompose Π into two n × r matrices such that Π=αβ′. The decomposition of Π implies that the $\beta' P_t$ are r stationary linear combination.

Johansen and Juselius, (1990) proposed two likelihood ratio test statistics (Trace and Max Eigen test statistics) to determine the number of cointegrating vectors are as follows:

$$J_{trace} = -T \sum_{i=r+1}^{N} 1n\left(1 - \hat{\lambda}_1\right)$$

$$\lambda_{\max} = -T1n\left(1 - \hat{\lambda}_{r+1}\right)$$

Where, r is the number cointegrated vector, $\hat{\lambda}_i$ is the eigenvalue and $\hat{\lambda}_{r+1}$ is the $(r + 1)^{th}$ largest squared eigenvalue obtained from the matrix Π and the T is the effective number of observation. The trace statistics tested the null hypothesis of 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).

Granger causality test

The notion of the Granger causality is that if the two variables are integrated of order one, i.e., I(1), then the most accepted way to know the causal relation between them is the Granger Causality proposed by Granger, (1969). The existing study also performed Granger Causality test which explained that the wholesale price in market A causes the price in market B if and only if the past values of market A provide additional information for the forecast of market B. The testing procedure of the Granger Causality involves three steps. In the first step, order of integration was tested applying the augmented Dickey-Fuller and Phillip-Perron test. After confirming the integration, Johansen and Juselius (1990) maximum likelihood approach was used to comprehend the cointegration between the markets. The Johansen cointegration test explained that if the cointegration exists among the variables, then Granger causality must also exist either unidirectional or bidirectional. The Granger causality involves estimation of the simple form of vector autoregressive model (VAR) and is presented as follows:

$$\ln P_t^A = \sum_{i=1}^{n} \delta_i \ln P_{t-1}^B + \sum_{j=1}^{n} \vartheta_i \ln P_{t-j}^A + \mu_{At}$$

$$\ln P_t^B = \sum_{i=1}^{n} \phi_i \ln P_{t-i}^B + \sum_{j=1}^{n} \partial_j \ln P_{t-j}^A + \mu_{Bt}$$

Where p_t are the wholesale prices and scripts A and B indicate the two separate markets, t is the time trend, μ_A and μ_B are the error terms of both the model.

The above mentioned two equations with respect to market A and B can be jointly tested using OLS and then conduct a *F*-test for the three different expression.

***Expression* – 1:** $[\delta_{11}, \delta_{12}, \ldots\ldots\delta_n] \neq 0$ and $[\partial_{21}, \partial_{22}, \ldots\ldots\partial_n] = 0$

Expression 1 indicates the unidirectional causality from lnP_t^B to lnP_t^A denoted as $lnP_t^B \rightarrow lnP_t^A$

***Expression* – 2:** [δ_{11}, δ_{12}, ……δ_n] = 0 and [∂_{21}, ∂_{22}, ……∂_n] ≠ 0

Expression 2 indicates the unidirectional causality from lnP_t^A to lnP_t^B denoted as $lnP_t^A \rightarrow lnP_t^B$

***Expression* – 3:** [δ_{11}, δ_{12}, ……δ_n] = 0 and [∂_{21}, ∂_{22}, ……∂_n] ≠ 0

Expression 3 indicates the bidirectional causality between lnP_t^A to lnP_t^B denoted as $lnP_t^A \leftrightarrow lnP_t^B$

When the sets of market A and market B coefficients are statistically significantly, it is said to be Feedback, or bilateral causality (Gujarati, 2003). Unidirectional causality from market A to market B is indicated if the estimated coefficient on the lagged of market B is statistically different from zero and *vice versa*.

Impulse Response Function

Granger causality test provides only the direction of causality for the selected time span. However, it fails to demonstrate effect of shock on future values. The impulse response function shows a specific point of time t_0, that a shock originates from one equation proceeds through the system (Kirchgässner *et al.*, 2012). Generalized impulse response function initially developed by the Koop *et al.* (1996) and since then many have added for development of both the theory and application of it. The existing study also applied the generalized impulse response and is specified as follows:

$$IRF_{t+k} = (u, P_t, P_{t-1} \ldots,) = E\,[P_{t+k} \mid P_t = p_t + u, P_{t-1} = p_{t-1} \ldots] - E\,[P_{t+k} \mid P_t = p_t, P_{t-1} = p_{t-1}, \ldots]$$

Where, lower case letters i.e., p represent realized values, and u is the impulse shock P_{t-1} is the history.

RESULTS AND DISCUSSION

The wholesale price trend of all the selected markets is presented in Fig. 1, which shows the symmetric behavior in the movement of prices in all the selected markets except Kozhikode, which is only the consuming market with no production. Onion prices in all the selected markets except Kozhikode have been rising steadily over the period with some brief episodes of sharp increase during December 2010 and September to November 2013. One of the plausible reasons of this sharp increase in the onion prices was supply shock due to bad weather condition. The maximum wholesale price of ₹ 5790/ quintal prevailed in Hyderabad and the minimum price was found in Kanpur ₹ 124/ quintal followed by Lasalgaon ₹ 200/ quintal as expected.

Descriptive Statistics

Summary statistics result shows that the price of onion remained highly volatile in Lasalgaon followed by Hyderabad as measured by coefficient of variation. The Lasalgaon is the Asia's biggest production of onion and the prices are dependent upon the demand of the other markets. The highest average prices of onion were found in Kozhikode market of high consumption with no production, while lowest average prices were in Mumbai and Lasalgaon, which were very near to the highest producing belt of onion (Table 1).

Table 1: Summary Statistics of the monthly wholesale Prices for fresh Onion in selected markets for the period January, 2006 to December, 2014 (in ₹/100 kg)

Statistics	Hyderabad	Kanpur	Kozhikode	Lasalgaon	Lucknow	Mumbai
Mean	1144.29	1079.93	1827.71	1085.83	1243.61	1044.59
Median	812.50	870.00	1621.50	701.00	1022.50	802.00
Max.	5790.00	4335.00	4568.00	5204.00	4741.00	4600.00
Min.	225.00	124.00	736.00	200.00	300.00	285.00
Std. Dev.	1004.29	762.05	883.83	978.84	853.78	751.03
CV	87.77	70.57	48.36	90.15	68.65	71.90

Order of the Integration

Typically, the Johansen's procedure necessitated that the time series should be integrated at order one, i.e., I (1). Both, the standard ADF and PP unit root tests, are applied to determine the order of integration. The unit root test regression implies that regressing the first difference of a series with its one period lag and several lags (as suggested by the various lag length criterion) of the first differenced series. Both the test tests the null hypothesis that the time series has unit root versus alternative no unit root. The null hypothesis of both the tests is accepted or rejected based on the critical value and corresponding probability value. If the test statistics is smaller in absolute terms than the critical values and the corresponding probability value is greater than 5% level, the series is said to be non-stationary. The results of the both the ADF and PP for logged onion price of six major markets at the level and

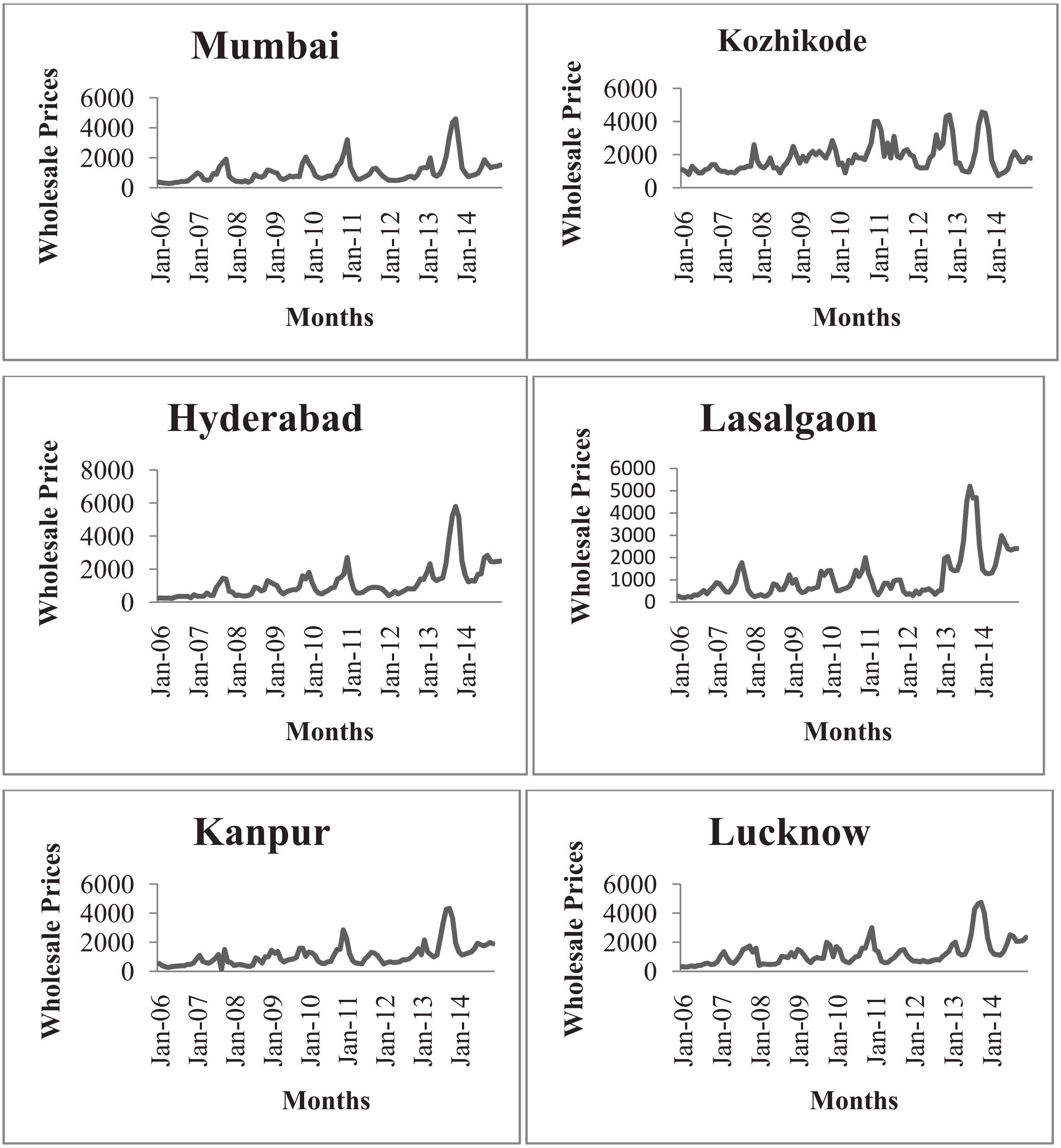

Fig. 1: Price behavior (₹/quintal) of onion in different selecting markets of India

at first difference are presented in Table 2. The price series in all the six markets (i.e., Hyderabad, Kanpur, Kozhikode, Lasalgaon, Lucknow and Mumbai) accepted the null hypothesizes of having unit root at their levels at 5% significance level and rejected at first difference which signifies that the underlying series are I(1). The number appropriate lag length is chosen as suggested by the Akaike Information Criterion (AIC).

Co-integration Analysis

In the next step, cointegration between the stationary price series has been tested by using Johansen's Trace and Maximum Eigen-value tests. 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

Table 2: ADF and PP Tests for Unit Root in the Prices of Onion

Augmented Dickey-Fuller test results at level				Phillips-Perron test results at level		
	t-Statistic	Prob.*	Remarks	t-Statistic	Prob.*	Remarks
lnHyderabad	-1.36	0.16	Non-stationary	-0.82	0.36	Non-stationary
lnKanpur	-1.43	0.14	Non-stationary	-1.02	0.28	Non-stationary
lnKozhikode	-1.47	0.13	Non-stationary	-0.95	0.30	Non-stationary
lnLasalgaon	-1.73	0.08	Non-stationary	-0.87	0.34	Non-stationary
lnLucknow	-0.44	0.52	Non-stationary	-0.76	0.39	Non-stationary
lnMumbai	-0.53	0.49	Non-stationary	-1.30	0.18	Non-stationary
Augmented Dickey-Fuller test results after differencing				**Phillips-Perron test results after differencing**		
ΔlnHyderabad	-6.08*	0.00	Stationary	-7.15*	0.00	Stationary
ΔlnKanpur	-6.50*	0.00	Stationary	-11.18*	0.00	Stationary
ΔlnKozhikode	-6.21*	0.00	Stationary	-11.92*	0.00	Stationary
ΔlnLasalgaon	-6.68*	0.00	Stationary	-7.25*	0.00	Stationary
ΔlnLucknow	-7.04*	0.00	Stationary	-8.17*	0.00	Stationary
ΔlnMumbai	-6.37*	0.00	Stationary	-8.56*	0.00	Stationary

Notes: ** denote significance at 1% levels of significance and Δ denote the first difference of the time series.*

PP tests. 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 cointegrating vectors between the selected onion markets. The results of Johansen's maximum likelihood tests (maximum eigen-value and trace test) are reported in Table 3. The first null hypothesis of maximum eigen-value and trace test, tests the no cointegration (r = 0) against the alternative hypothesis (r ≥ 1) of at least one cointegrated equation prevailed in the VAR system. Both, the maximum eigen-value and trace test reject the null hypothesis of no cointegration. The rejection/acceptance of the null hypothesis is decided by the trace max- eigen test statistics values against their critical value and corresponding probability value which is less than test statistic in the first null hypothesis. Similarly, the null hypotheses from r ≤ 1 to r ≤ 3, for both the statistics were rejected against their alternative hypotheses from the r ≥ 1 to r ≥ 3, as their critical values are less than the test statistics and the corresponding probability values are also less than 0.05. This implies that there are four co-integrating relationships in the joint co-integration analysis of all six onion markets.

Table 4 shows the results of bivariate Trace and Maximum Eigen-value tests. For all the onion markets pairs, the first null hypothesizes of r=0 are rejected as the critical value is less than both from the trace and max Eigen statistics, and corresponding probability value is also less than 5% level of significance. The result clearly indicates that there exists one cointegration equation in each pair of the markets. The empirical decision proposes that the onion prices in India are cointegrated in the long run. The results of both the Trace and Maximum Eigen-value tests can also be interpreted as the prices of onion in India move together in the long equilibrium. Hence, it can be concluded that onion markets of the India are efficiently functioning. Moreover, the Johansen's Trace and Maximum Eigen-value tests signify that the wholesale prices in these onion markets are competitive. In the competitive markets, the movements of the prices are closely associated. The study has conformity with most of the regional research work, which also revealed that the domestic onion markets are efficiently functioning and prices are well transmitted and cointegrated (Reddy *et al.*, 2012; Sendhil *et al.*, 2014; Rajendran, 2015). The null hypotheses for both the trace and trace max Eigen statistics are no cointegration equation against the alternative hypothesizes of at least one cointegration equation are rejected in all the cases. The acceptance and rejection of the null hypothesize are based on the critical test value and corresponding probability value. All the markets pairs depict that one

Table 3: Joint Cointegration Test Results Logged onion Market prices in India

Markets	H_0	H_1	Trace Statistics results			Max-Eigen Statistics results		
			Trace Statistics	0.05 Critical Value	P-Value	Max-Eigen Statistic	0.05 Critical Value	P-Value
lnHyderabad	r =0	r≥1	197.807*	95.7537	0.0000	88.2357*	40.07757	0.0000
lnKozhikode	r≤1	r≥2	109.571*	69.8189	0.0000	44.1279*	33.87687	0.0022
lnMumbai	r≤2	r≥3	65.4429*	47.8561	0.0005	28.4681*	27.58434	0.0385
lnLasalgaon	r≤3	r≥4	36.9749*	29.7971	0.0063	21.6013*	21.13162	0.0429
lnKanpur	r≤4	r≥5	15.3735	15.4947	0.0521	11.954	14.2646	0.1124
lnLucknow	r≤5	r=6	3.41949	3.84147	0.0644	3.41949	3.841466	0.0644

Notes: *ln represent the natural logarithm and * denote the rejection of null hypothesis at 5% level of significance*

Table 4: Pair-wise Johansen co-integration test results for the prices of Onion

Markets pair	H_0	H_1	Trace Statistics results			Max-Eigen Statistics results		
			Trace Statistics	0.05 Critical Value	P-Value	Max-Eigen Statistic	0.05 Critical Value	P-Value
Hyderabad-Kanpur	r =0	r≥1	22.16*	12.32	0.00	18.84*	11.22	0.00
	r≤1	r≥2	3.31	4.13	0.08	3.31	4.13	0.08
Hyderabad-Kozhikode	r =0	r≥1	31.88*	20.26	0.00	25.17*	15.89	0.00
	r≤1	r≥2	6.71	9.16	0.14	6.71	9.16	0.14
Hyderabad-Lasalgaon	r =0	r≥1	22.46*	12.32	0.00	19.62*	11.22	0.00
	r≤1	r≥2	2.84	4.13	0.11	2.84	4.13	0.11
Hyderabad-Lucknow	r =0	r≥1	16.02*	12.32	0.01	13.00*	11.22	0.01
	r≤1	r≥2	3.02	4.13	0.10	3.02	4.13	0.10
Hyderabad-Mumbai	r =0	r≥1	28.82*	20.26	0.00	26.26*	15.89	0.00
	r≤1	r≥2	2.56	9.16	0.66	2.56	9.16	0.66
Kanpur-Kozhikode	r =0	r≥1	14.16*	12.32	0.02	11.34*	11.22	0.02
	r≤1	r≥2	2.82	4.13	0.11	2.82	4.13	0.11
Kanpur-Lasalgaon	r =0	r≥1	16.01*	12.32	0.01	12.94*	11.22	0.01
	r≤1	r≥2	3.07	4.13	0.09	3.07	4.13	0.09
Kanpur-Lucknow	r =0	r≥1	23.63*	12.32	0.00	20.18*	11.22	0.00
	r≤1	r≥2	3.46	4.13	0.07	3.46	4.13	0.07
Kanpur-Mumbai	r =0	r≥1	25.71*	12.32	0.00	22.88*	11.22	0.00
	r≤1	r≥2	2.83	4.13	0.11	2.83	4.13	0.11
Kozhikode-Lasalgaon	r =0	r≥1	32.77*	20.26	0.00	25.99*	15.89	0.00
	r≤1	r≥2	6.77	9.16	0.14	6.77	9.16	0.14
Kozhikode-Lucknow	r =0	r≥1	12.33*	12.32	0.05	9.48*	11.22	0.05
	r≤1	r≥2	2.86	4.13	0.11	2.86	4.13	0.11
Kozhikode-Mumbai	r =0	r≥1	17.30*	12.32	0.01	14.40*	11.22	0.01
	r≤1	r≥2	2.9	4.13	0.10	2.9	4.13	0.10
Lasalgaon-Lucknow	r =0	r≥1	37.91*	20.26	0.00	29.93*	15.89	0.00
	r≤1	r≥2	7.98	9.16	0.08	7.98	9.16	0.08
Lasalgaon-Mumbai	r =0	r≥1	33.69*	20.26	0.00	30.69*	15.89	0.00
	r≤1	r≥2	3.37	9.16	0.51	3.37	9.16	0.51
Lucknow-Mumbai	r =0	r≥1	28.32*	12.32	0.00	27.09*	11.22	0.00
	r≤1	r≥2	1.23	4.13	0.31	1.23	4.13	0.31

Note: ** denote significance at 1% levels of significance*

Tables 5: Market pair wise results of the Granger Casualty test

Markets Pairs	No. of Obs.	F-Statistic	P-Value	Decision of null hypothesis	Remarks
Kanpur-Hyderabad	106	0.3	0.7375	Reject	Unidirectional
Hyderabad-Kanpur	106	19.94*	0.0000	Do not reject	No causality
Kozhikode-Hyderabad	106	1.22	0.2968	Reject	No causality
Hyderabad-Kozhikode	106	4.64**	0.0118	Do not reject	Unidirectional
Lasalgaon-Hyderabad	106	9.19*	0.0002	Do not reject	Unidirectional
Hyderabad-Lasalgaon	106	1.99	0.1418	Reject	No causality
Lucknow-Hyderabad	106	4.22**	0.0173	Do not reject	Bi-directional
Hyderabad-Lucknow	106	4.44**	0.0142	Do not reject	Bi-directional
Mumbai-Hyderabad	106	10.72*	0.0000	Do not reject	Unidirectional
Hyderabad-Mumbai	106	1.9046	0.1542	Reject	No causality
Kozhikode-Kanpur	106	1.4953	0.2291	Reject	No causality
Kanpur-Kozhikode	106	8.667*	0.0003	Do not reject	Unidirectional
Lasalgaon-Kanpur	106	30.04*	0.0000	Do not reject	Unidirectional
Kanpur-Lasalgaon	106	1.326	0.2701	Reject	No causality
Lucknow-Kanpur	106	24.0841*	0.0000	Do not reject	Unidirectional
Kanpur-Lucknow	106	0.15259	0.8587	Reject	No causality
Mumbai-Kanpur	106	27.3588*	0.0000	Do not reject	Bi-directional
Kanpur-Mumbai	106	5.04886*	0.0081	Do not reject	Bi-directional
Lasalgaon-Kozhikode	106	3.2535**	0.0427	Do not reject	Bi-directional
Kozhikode-Lasalgaon	106	1.58422	0.2102	Reject	No causality
Lucknow-Kozhikode	106	6.4254*	0.0024	Do not reject	Bi-directional
Kozhikode-Lucknow	106	0.55076	0.5782	Reject	No causality
Mumbai-Kozhikode	106	9.05133*	0.0002	Do not reject	Bi-directional
Kozhikode-Mumbai	106	0.08769	0.9161	Reject	No causality
Lucknow-Lasalgaon	106	3.6366**	0.0298	Do not reject	Bi-directional
Lasalgaon-Lucknow	106	11.0934*	0.0000	Do not reject	Bi-directional
Mumbai-Lasalgaon	106	7.1553*	0.0012	Do not reject	Bi-directional
Lasalgaon-Mumbai	106	9.71484*	0.0001	Do not reject	Bi-directional
Mumbai-Lucknow	106	2.589***	0.0800	Do not reject	Bi-directional
Lucknow-Mumbai	106	4.5379**	0.0130	Do not reject	Bi-directional
Lucknow-Mumbai	106	4.5379**	0.01300	Do not reject	Bi-directional

Note: **, **, *** represents the level of significance at 1%, 5% and 10% respectively*

cointegration equation is prevailing in each pair. The cointegration of the onion prices signifies that there is long-run equilibrium relationship between all the pairs of selected onion markets.

Granger causality test

After confirming the integration of prices series, in the next step, we have performed pair-wise Granger causality test for six onion markets to comprehend causal relation between them. Granger causality test, tests the null hypothesis of no causality between the selected pairs of onion markets. The results presented in Table 5 explicates that the few market pairs such as Lucknow–Hyderabad, Mumbai–Kanpur, Mumbai–Lasalgaon and Mumbai–Lucknow have bidirectional causality. 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. The rest of the market pairs have unidirectional causality. It means that a price change in the former market in each pair granger cause 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. Lasalgaon, Mumbai and Lucknow granger cause the price formations in rest of the markets, whereas Hyderabad and Kanpur granger cause price in three and two markets respectively. Kozhikode does not granger cause price formation in any of the markets.

Impulse Response Function Analysis

The impulse response function explicates the responsiveness of one of the endogenous variable due to the shock on the current and future values of all the other endogenous variables in the VAR system. The shock affects the variable itself, and it is also transmitted to all other explanatory variables (Bhanumurthy *et al.*, 2012). The results of the impulse response function analysis are given in the Appendix A: Figure 1 to 6. Figure 1 to 6 illustrates the impact of shocks transmitting over to other onion markets. All the selected onion markets highly responded to standard deviation shock in any of these markets, except Kozhikode and Mumbai where the shock started disappearing during 6 to 7 months. The standard deviation shock given to Lucknow, Hyderabad, Kanpur and Lasalgaon are transmitted to a greater extent implying that these markets are the onion price maker markets. On the contrary, the one standard deviation shock given to Mumbai and Kozhikode are relatively lesser transmitted implying that these markets are price followers.

CONCLUDING REMARKS

The present study analyzed market integration and price transmission in six major onion markets using Johansen's cointegration, Granger causality test and impulse response function. All the market pairs are well cointegrated, which implies that the onion prices have an equally long run association. The Granger causality test indicates Lucknow-Lasalgaon, Mumbai-Lasalgaon, Lucknow-Mumbai, Lucknow–Hyderabad and Mumbai-Kanpur have bidirectional causality, while the rest of the markets have unidirectional causality except Kozhikode. Kozhikode being a consuming market does not granger cause price formation in any of the other selected markets. The impulse response function revealed that standard deviation shocks given to any market are transmitted quickly to all other markets except Mumbai and Kozhikode, implying both the markets are price followers. One of the possible reasons might be that Mumbai is the largest supplier market, and the Kozhikode, which is the geographically dispersed, is an import market with a sea port, where foreign produce might arrived in a larger quantity. The overall results of the study suggest that regional markets for onion in India are strongly cointegrated, which limit the government intervention and allows the private traders.

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Appendix

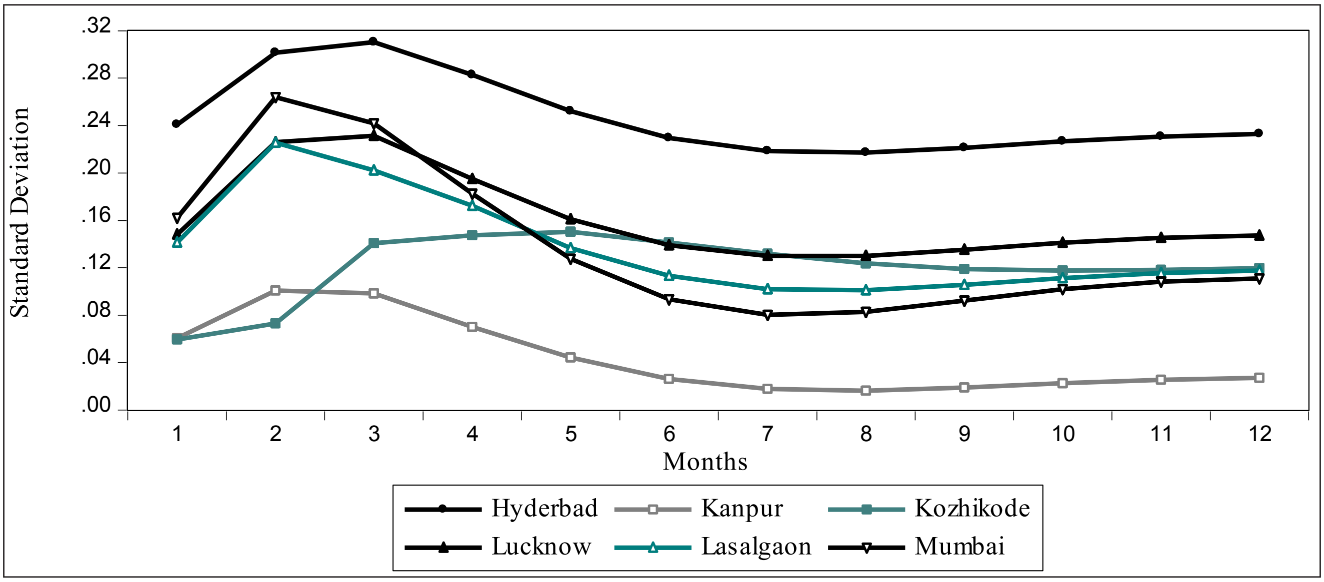

Fig. 1: Response of Hyderabad to Generalized One Standard Deviation Innovations

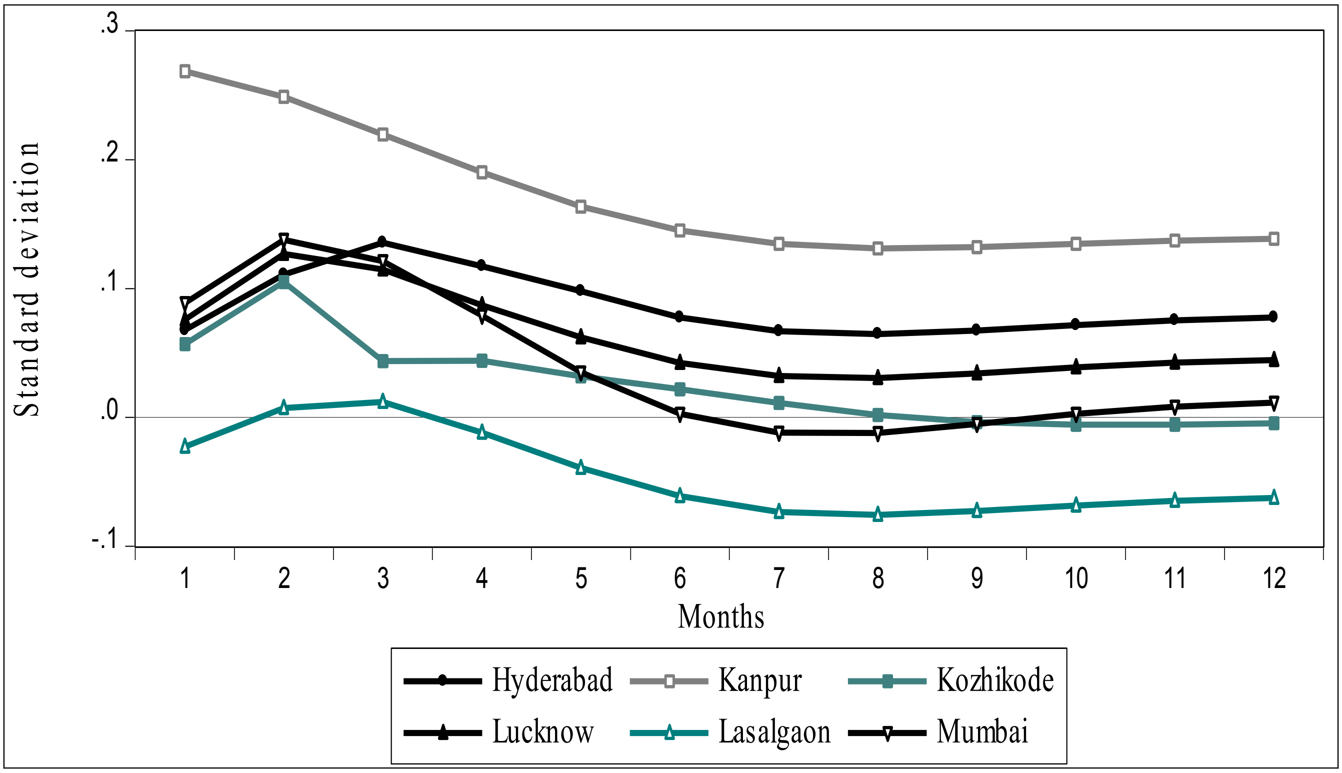

Fig. 2: Response of Kanpur to Generalized One Standard Deviation Innovations

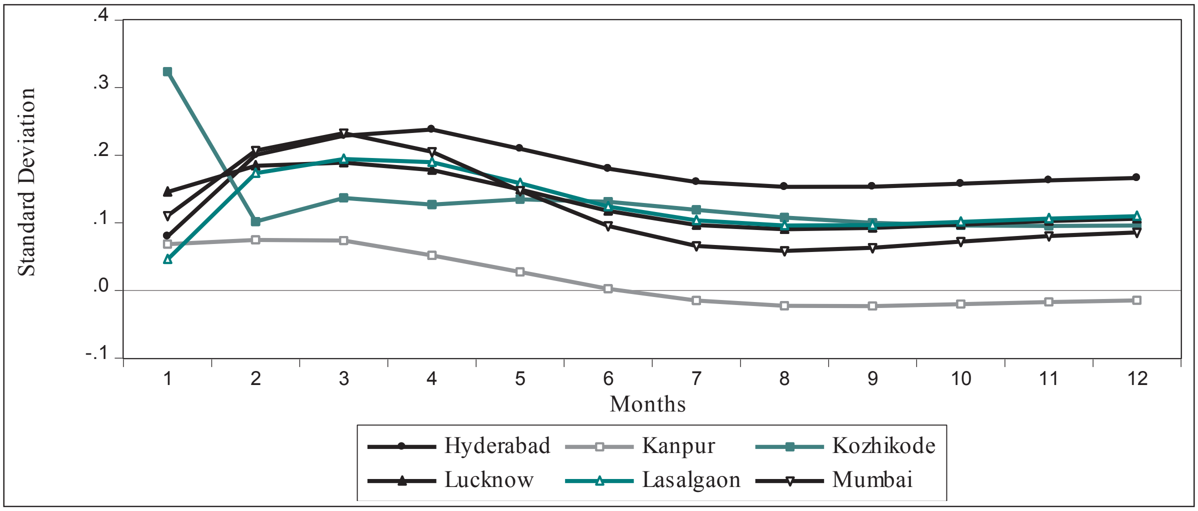

Fig. 3: Response of Kozhikode to Generalized One Standard Deviation Innovations

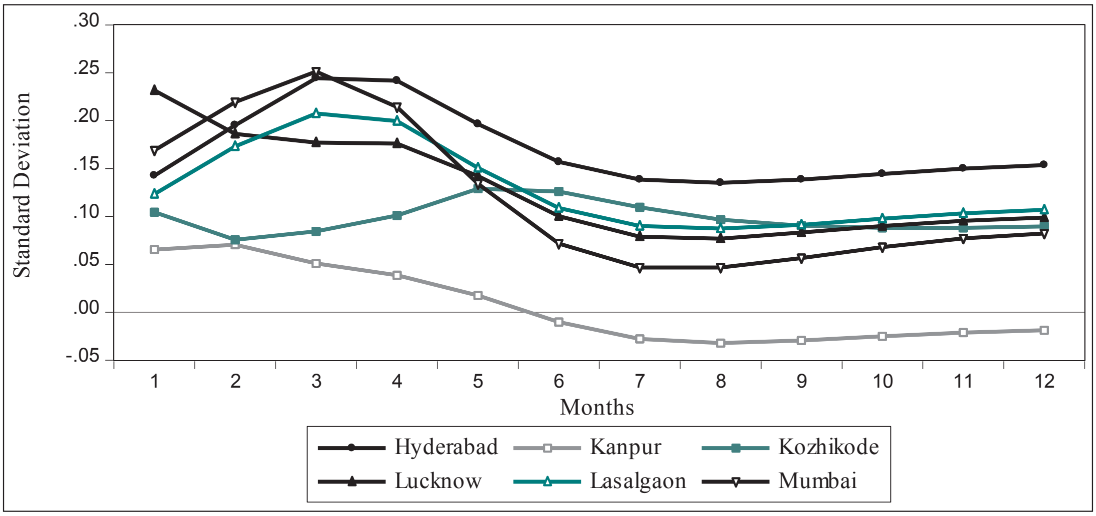

Fig. 4: Response of Lucknow to Generalized One Standard Deviation Innovations

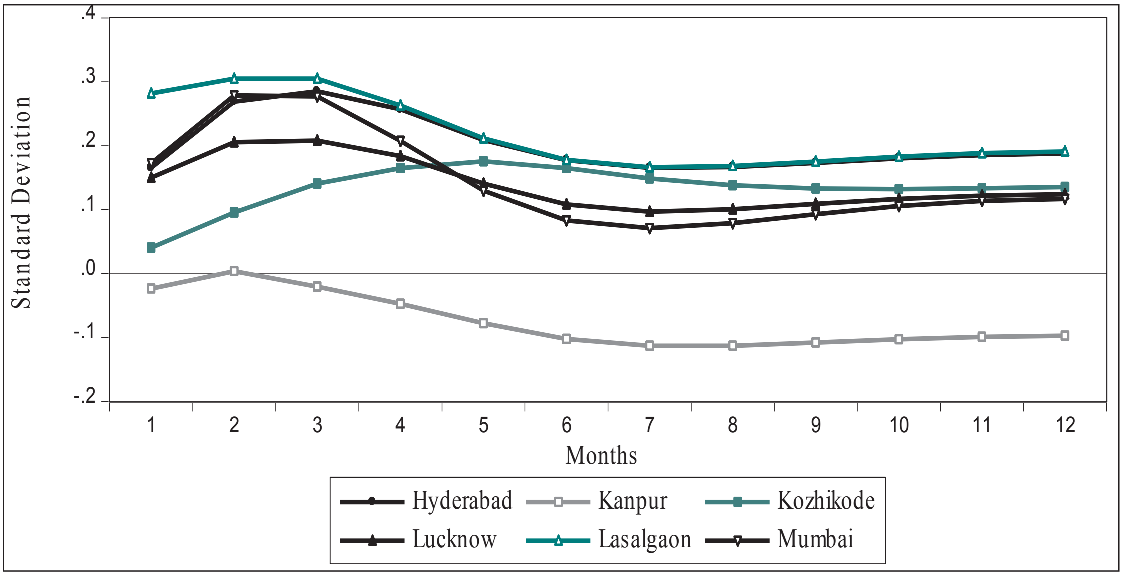

Fig. 5: Response of Lasalgaon to Generalized One Standard Deviation Innovations

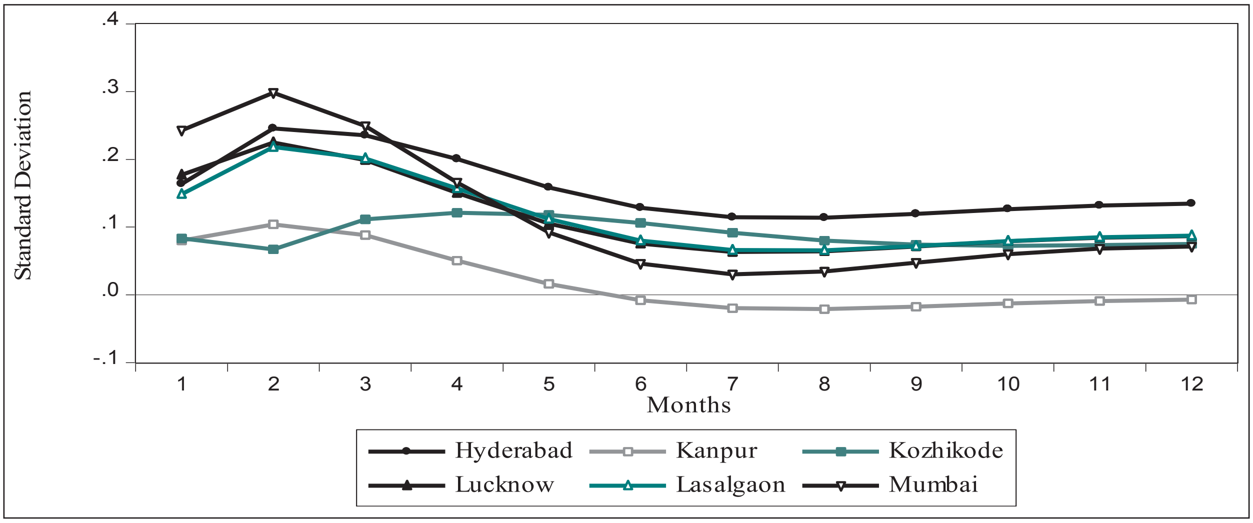

Fig. 6: Response of Mumbai to Generalized One Standard Deviation Innovations