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Market linkages for the major onion markets in India

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ABSTRACT

India is the second largest producer of onion in the world. Though newer states, like Bihar and Madhya Pradesh, are emerging in onion production; onion is still largely concentrated in the states of Maharashtra and Karnataka, one dominating in *rabi* onion and the other one in *kharif* onion. Despite tremendous production growth and trade opportunities, India suffers from very high volatility in onion production. Markets in the leading state i.e., Maharashtra, are pre-dominant in terms of onion supply and distribution and thereby creating strong influences on other markets. Lasalgaon, Pimpalgaon, Bangalore and Solapur are the major markets transmitting price signals to other major consuming and producing markets. The market surveillance needs to be given due priority to control for any imperfections and malpractices arising due to advance signals. The instability in production can be reduced by diluting regional concentration of onion production. Stabilisation through stocks by public sector agencies like NAFED will help reducing the exploitation and market manipulation by private traders. The storage capacity needs to be enhanced at the grass root level. Effective use of Government schemes like "Price Stabilisation Fund" and "Operation Greens" would help in creating mechanisms and logistics to control the price volatility.

Key words: Onion prices, price transmission, vector auto-regression.

INTRODUCTION

Due to diverse agro-climatic conditions in India, a wide variety of agricultural items are produced throughout the year. In 2016-17, India produced 175 million tonnes of vegetables from 10.3 million hectares; onion was the second largest grown vegetable next to potato. Onion has emerged among the fastest growing crops among various high value products in recent years. Onion production in India was characterised by high growth and high volatility with a turnaround in production after 2002-03 and continues till date. High growth in onion production was accompanied with very high year to year fluctuations in output.

Despite very impressive growth in output, onion has remained achilles heel of the policy planners due to frequent and often violent price spikes. Onion price shocks have become a recurrent phenomenon hitting almost every alternate year, hurting both the producers as well as consumers. Onion suffers from a significantly price volatility across spatial and temporal dimensions (Sharma *et al.*, 18; Chengappa *et al.*, 2; Gummagolmath, 4; Kasturi, 9; Saxena and Chand, 16). Any undue upward movement of onion price is bound to leave a ripple effect on the household food budget as the majority of consumers consume onion as part of their daily diets (Chengappa *et al.*, 2). On the other hand, when prices dip below the cost of cultivation, onion farmers get adversely affected. Even among the "TOP" (tomato, onion and potato) identified as the most price sensitive commodities, onion remains the most vulnerable commodity with instability of 49.3 per cent during 2011-16. While the unpredictable climatic condition is cited as the most prominent cause of price volatility, studies have also acknowledged the role of collusive tendencies of the market intermediaries behind the price shocks (Chand *et al.*, 1; Sharma *et al.*, 18; Chengappa *et al.*, 2; Kasturi, 9; Kalamkar and Makwana, 8).

Thus, controlling the price instability of onion is a major concern for the politicians, policymakers and academicians. This paper aims at objectively examining the claim by applying a scientific approach and intends to explore the onion price shocks taking into account the geographical concentration of onion and its linkages to consuming zone, historical evidences of price shocks, markets integration and capturing the price transmission signals with degree of influence. These implications would be helpful in advanced production planning, identifying critical markets and phases in generating price shocks and finally delineating the strategies to control onion price shocks and crisis in India.

MATERIALS AND METHODS

The analysis is based on time series weekly data on prices and arrivals of onion from January, 2005 to February, 2017 collected from the National

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Horticultural Research and Development Foundation (NHRDF, 10) for twelve major onion producing and consuming markets of India. These include Delhi, Mumbai, Chennai and Kolkata as major consuming markets. Major onion producing states are Maharashtra (6735 Thousand tons; 30 per cent), Madhya Pradesh (3722 Th. Tons; 16.6 per cent), Karnataka (3049 Th. tons; 13.6 per cent), Gujarat (1290 Th. tons; 5.8 per cent) and Bihar (1249 Th. tons; 5.6 per cent) of total onion productions in 2016-17. Lasalgaon, Pimpalgaon, Pune and Solapur markets in Maharashtra; Bangalore (the name recently changed as Bengaluru) market in Karnataka; and Indore market in Madhya Pradesh; Patna in Bihar; Mahuva market in Gujarat, were selected as major producing states markets. Price transmission analysis was undertaken to examine the linkages and transmission of onion prices to different domestic markets. The markets were selected on the basis of market arrivals of onion. The market linkages can be measured in terms of the strength and speed of price transmission between markets across various regions of the country. The degree which consumers and producers would benefit depends on how domestic markets are integrated with each other (Varela *et al.*, 19). The details of price linkages in onion and other agricultural commodities can be found in Paul *et al.* (11), Saxena *et al.* (15), and Paul *et al.* (12) and (13).

The analysis involved the following steps:

Stationarity Test: Stationarity (unit root) test should be carried out to test for the order of integration. In literature, several tests for testing presence of unit root are available. Among them, Augmented Dickey-Fuller (ADF) unit root test (Dickey and Fuller, 3) and Philips Perron (PP) test (Philips and Perron, 14) are most widely used. The ADF, PP and KPSS tests (Kwiatkowski *et al*., 7) were conducted for examining the stationarity in onion price series. The options were tried with trend and intercept and without trend and intercept also. However, the price series were stationary at level under all options with and without intercept and trend. Thus, the Vector Auto-regression (VAR) Model was applied to study the price linkages.

Estimating VAR: VAR model is the generalized form of univariate Autoregressive (AR) model. It is used to capture the linear dependencies among multiple time-series processes. All variables in a VAR enter the model in the same way: each variable has an equation explaining its evolution based on its own lagged values, the lagged values of the other model variables, and an error term. A VAR model describes the evolution of a set of K variables (called endogenous variables) over the same sample period (t = 1,2, ...,T) as a linear function of only their past values. The basic form of a p^{th} order VAR model, denoted by VAR (p) is

$$yt = Dd_t + A_1 Y_{t-1} + A_2 Y_{t-2} + ... + A_p Y_{t-p} + e_t$$

where Yt = $(Y_{1t}, Y_{2t}, ..., Y_{Kt})'$ (the prime denotes the transpose) is a vector of K observed time-series variables, Y_{it} denotes the observation at the time t of the ith variable, d_t is a vector of deterministic terms such as a constant, a linear trend and/or seasonal dummy variables, D is the associated parameter matrix, the A_i's are ($K \times K$) parameter matrices attached to the lagged values of Y_t, p is the lag order or VAR order and e_t is an error process.

Structural Breaks: Detection of change points in a series is very important to correctly interpret the behaviour of the series. For single structural change, At most one Change point (AMOC) algorithm has been applied for identification of structural breaks in onion export prices. The algorithm for detection of multiple change points in a series was first given by Inclan and Tiao (5) in the form of Iterated Cumulative Sum of Squares (ICSS)**.** In recent years using this algorithm efficient method for multiple change points detection has been developed as Pruned Exact Linear Time (PELT) by Killick *et al.* (6). PELT has been applied for identification of multiple structural breaks in domestic prices of onion (wholesale price index) to understand the price trajectory.

RESULTS AND DISCUSSION

India is the second biggest player in global onion market after China. The trends in area, production and productivity of onion since 1974-75 are presented in Fig. 1; the first phase from 1974-75 to 2002-03 witnessed gradual increase in production driven largely by area expansion. In this period, area under onion cultivation doubled from 0.2 million hectares to 0.4 million hectares and production also doubled (since 2003-04). However, the yield levels remained stagnant at 100 quintals per hectare. After 2002-03, all three dimensions of production witnessed exponential growth. In ten years following 2002-03, onion productivity increased by about 60 per cent which attracted area shift in favour of onion. The increase in area turns out to be much higher (more than double) in 10 years period. As a result, onion production tripled in less than 10 years since 2002-03.

Maharashtra is the highest onion producing state in India contributing about 30 per cent of the total production in the country, followed by Karnataka. Eight states namely Andhra Pradesh, Bihar, Gujarat, Haryana, Karnataka, Madhya Pradesh, Maharashtra and Rajasthan comprised of 85 per cent of onion production in TE 2015-16 and accounted for 83 per cent of area share. Rest of the states produce

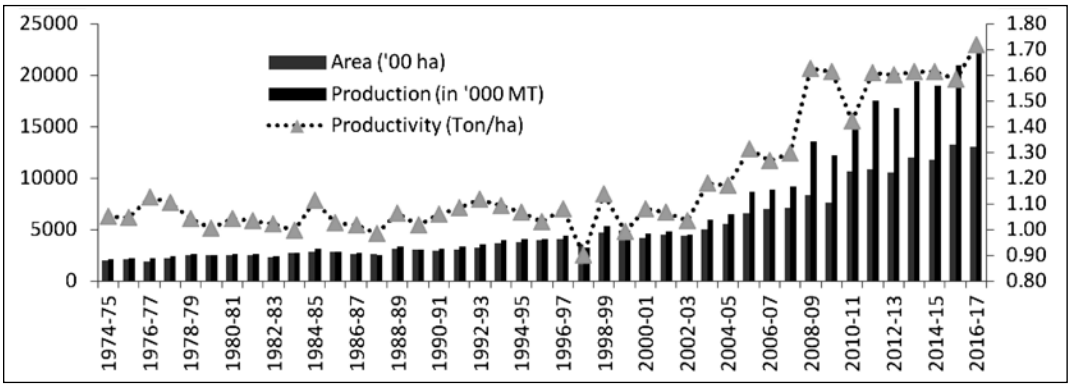


Fig. 1. Area, production and productivity of onion in India (1974-75 to 2016-17)
Source: NHRDF(10).

only 15 per cent of the onion in the country. Onion is grown in varied agro-climatic conditions ranging from southern, western, and northern to central zone climatic conditions. Geographic concentration of onion production has changed in last 15 years. Bihar and Madhya Pradesh are the emerging states in onion production. Maharashtra accounted for 35 per cent of the onion area and 30 per cent of the onion production in the country in TE 2015-16.

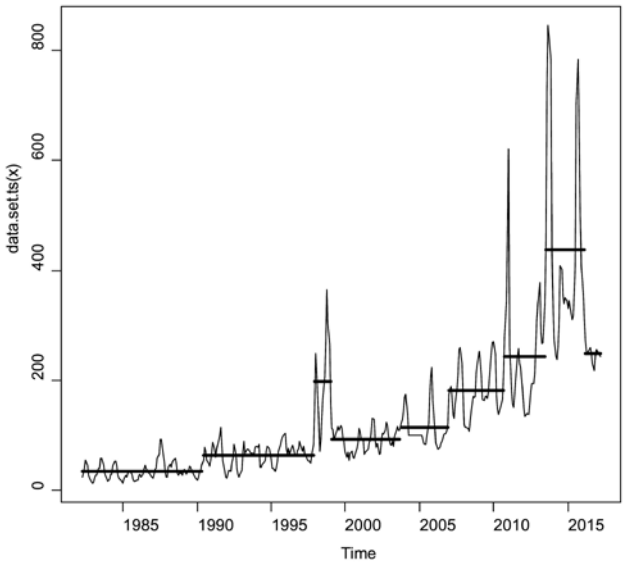
Maharashtra, Madhya Pradesh and Bihar are the *rabi* dominating states while Karnataka, Andhra Pradesh, Rajasthan and Gujarat supply maximum quantity in *kharif* season.Onion is largely produced in Nashik, Pune and Ahmednagar districts of Maharashtra state; three crops of onions are marketed in Maharashtra with about 10-15 per cent during *Kharif* (harvested during September-December), 30-40 per cent as late *kharif* (harvested during January-March) and as much as 50-60 per cent *rabi* crop harvested during summer season (March-May). Lasalgaon mandi, in Nashik district of Maharashtra, is Asia's largest onion market. The onions from Lasalgaon are supplied to many places in India and also exported to many countries. At national level, close to 50-60 per cent of the onions are produced in *rabi* season and remaining 40-50 per cent are produced in *kharif* and late *kharif*. A large proportion of the *rabi* onion comes from Maharashtra. The *rabi* onion starts arriving in April and has better shelf life as compared to *kharif* onion. *Rabi* onions can be stored for 4-5 months and consumed till September before the arrival of *kharif* onions beyond September, majority of which comes from Karnataka and Andhra Pradesh.

Uncertainties on the production front coupled with marketing inefficiencies usually are responsible for onion price volatility in India. Saxena *et al.* (17) established that the farmers loose significantly due to the increasing onion price instability in India. The growth in onion production shows that it is the lagged production that determines the current period onion price shocks. In year 2012-13, onion production in Maharashtra (the leading onion producing state) declined by 17 per cent and caused 238 per cent increase in its price in the following year. In the next year, onion production increased by 26 per cent and the price declined by 43 per cent. This led to a decline in the gross revenue by 28 per cent. The cycle repeated in the next two years also. Such volatility in prices needs to be curbed through proper market information and intelligence efforts.

The abrupt price changes detection from a statistical point of view corresponds to estimating the points which exhibit significant change in the statistical properties of a sequence of observations. In order to find out multiple change points in the variance of wholesale price index of onion, the Pruned Exact Linear Time (PELT) method has been used. The locations of structural breaks have been depicted in Fig. 2; total 9 breaks have been noted in the data. Onion WPI touched the highest value of 619 in January 2011. In 2013, highest ever onion WPI was recorded in September 2013. Year 2015 also led the WPI to jump to an index of 758, which was, of course, lower than the previous shocks. Even the price spikes were observed during October to December, 2017 and are linked to production and market arrival pattern. Prices started increasing from late September and have continuously increased till December 2017. The instability in onion price index has become much more pronounced particularly after 2005. The dissection of breaks reveals that the length of price stability phases has reduced overtime and shorter phases with greater instability are becoming pronounced. The instability is largely driven by the changes on production front.

As the price shocks in the economy are becoming more regular feature, it becomes important to analyse the price triggers and the linkages among markets. Table 1 and Table 2 present the price transmission in major producing and consuming markets. Box 1 summarizes the response of major consuming and producing markets due to price shocks in producing markets. Lasalgaon, Bangalore and Solapur remain the most influential producing markets causing the change in consuming markets besides their own influence. Major change has been observed in terms of influence of previous week prices in these markets. It is noted that one unit change in Lasalgaon market in the preceding week would be able to enhance Kolkata, Mumbai and Delhi markets by 0.45, 0.42 and 0.39 units, respectively and vice-versa in the following week, however, the sustained response has not been noticed. The influence of Bangalore is most pronounced in Kolkata. In terms of consuming market linkages, Chennai-Bangalore, Delhi-Lasalgaon-Bangalore, Kolkata-Lasalgaon-Bangalore and Mumbai-Lasalgaon are the important interdependent markets which need to be efficiently linked with each other. These markets create immediate influence and thus market surveillance is important here.

A different story can be entwined when the influence of selected markets on major producing markets is analysed. Pimpalgaon and Bangalore are the most important markets influencing Indore, Lasalgaon, Mahuwa, Patna and Pimpalgaon besides their own influence. One unit change in Pimpalgaon markets is able to bring 0.32, 0.31, 0.20 in Patna, Indore, Lasalgaon, respectively. Pimpalgaon and Lasalgaon are the most important primary markets dealing with *rabi* onion. At the same time, Bangalore dominates in terms of *kharif* onion supply and transmits the signals accordingly. These markets need to be given due consideration in terms of market surveillance.



Phase Vs	Phase	t-statistic	p-value	F statistic	p-value
Apr, 1982 to May, 1990	Jun, 1990 to Nov, 1997	-11.34	<0.0001	1.68	0.01
Jun, 1990 to Nov, 1997	Dec, 1997 to Jan, 1999	-5.92	<0.0001	18.17	<0.0001
Dec, 1997 to Jan, 1999	Feb, 1999 to Sep 2003	4.68	0.01	17.66	<0.0001
Feb, 1999 to Sep 2003	Oct, 2003 to Dec, 2006	-3.55	0.00	3.12	<0.000
Oct, 2003 to Dec, 2006	Jan, 2007 to Sep, 2010	-7.60	0.07	1.68	0.10
Jan, 2007 to Sep, 2010	Oct, 2010 to Jun, 2013	-3.20	0.00	5.22	<0.0001
Oct, 2010 to Jun, 2013	Jul, 2013 to Feb 2016	-5.20	<0.0001	3.07	<0.0001
Jul, 2013 to Feb 2016	Mar, 2016 to Mar, 2017	5.77	<0.0001	183.17	<0.0001

Fig. 2. Structural breaks in onion wholesale price index in India as evident through change in mean and variance

Box 1. Summary of price influence among major onion producing and consuming markets

Indian Zone	Major onion producing States	Major onion Markets	Producing Markets: Bangalore	Indore	Lasalgaon	Mahuva	Patna	Pimpalgaon	Pune	Solapur	Consuming Markets: Chennai	Delhi	Kolkata	Mumbai
Central	Madhya Pradesh	Indore												
North	Bihar	Patna									■	■	■	
South	Karnataka	Bangalore		■	▤	▤	■	■		■	▤	■	▤	■
West	Maharashtra	Lasalgaon	■				■	■	▤	■		▤	▤	▤
	Maharashtra	Pimpalgaon		▤	■	■	▤							
	Maharashtra	Pune						■			■			
	Maharashtra	Solapur		■	■			■			■	■	■	■
	Gujarat	Mahuva									■			

Note: Only positive response and other influenced market have been considered.

Major response ▤ Least response ■ No responsive □

Table 1. Transmission of price signals to major consuming markets.

Consuming markets (Dependent market where change is caused)	Initial Triggering markets (change in previous week price)	Transmission coefficient (Unit change in dependent market)	Markets with prolonged and delayed response (With lag of two weeks)	Transmission coefficient (Unit change in dependent market)
	1 unit change in Markets below		1 unit change in Markets below	
Chennai	Chennai	0.47	Bangalore	-0.22
	Bangalore	0.35	Kolkata	0.14
	Mumbai	0.20	Mahuva	-0.14
	Pune	0.17	Chennai	0.12
	Solapur	0.17		
	Patna	0.16		
	Mahuva	0.13		
Delhi	Delhi	0.63	Lasalgaon	-0.26
	Lasalgaon	0.39	Mahuva	-0.15
	Bangalore	0.23	Patna	0.14
	Solapur	0.15	Mumbai	0.16
	Chennai	-0.11	Bangalore	-0.13
	Patna	-0.11	Indore	0.10
Kolkata	Lasalgaon	0.45	Mahuva	-0.32
	Bangalore	0.40	Kolkata	0.30
	Kolkata	0.37	Lasalgaon	-0.28
	Solapur	0.23	Bangalore	-0.24
	Mumbai	0.18	Solapur	-0.21
	Patna	-0.14	Chennai	0.11
Mumbai	Mumbai	0.75	Lasalgaon	-0.33
	Lasalgaon	0.42	Mahuva	-0.19
	Solapur	0.19	Indore	0.12
	Bangalore	0.18		
	Chennai	-0.16		

Note: The coefficients are significant at 5 per cent level of significance.

Table 2. Transmission of price signals to major producing markets.

Producing markets (Dependent market where change is caused)	Initial Triggering markets (change in previous week price)	Transmission coefficient (Unit change in dependent market)	Markets with prolonged/ delayed response (With lag of two weeks)	Transmission coefficient (Unit change in dependent market)
	1 unit change in Markets		1 unit change in Markets	
1	2	3	4	5
Bangalore	Bangalore	0.89	Mahuva	-0.20
	Mumbai	0.26	Indore	0.14
	Lasalgaon	0.17		
Indore	Indore	0.51	Pimpalgaon	-0.25
	Pimpalgaon	0.31	Indore	0.21
	Bangalore	0.25	Lasalgaon	-0.21
	Patna	-0.22	Delhi	-0.18

1	2	3	4	5
			Solapur	0.14
Lasalgaon	Lasalgaon	0.75	Indore	0.23
	Bangalore	0.30	Delhi	-0.22
	Pimpalgaon	0.20	Patna	0.13
	Patna	-0.17		
	Solapur	0.15		
	Mahuva	-0.15		
	Chennai	-0.12		
Mahuva	Mahuva	0.52	Patna	0.25
	Bangalore	0.32	Pimpalgaon	-0.20
	Patna	-0.19	Delhi	-0.18
	Pimpalgaon	0.16	Bangalore	-0.14
	Chennai	-0.10	Pune	0.10
Patna	Lasalgaon	0.41	Lasalgaon	-0.23
	Patna	0.38	Mahuva	-0.22
	Pimpalgaon	0.32	Mumbai	0.21
	Bangalore	0.26	Patna	0.17
	Pune	-0.17	Bangalore	-0.17
	Chennai	-0.16	Pune	0.14
Pimpalgaon	Pimpalgaon	0.66	Delhi	-0.19
	Bangalore	0.32	Indore	0.15
	Lasalgaon	0.22	Bangalore	-0.13
	Solapur	0.19		
	Pune	0.14		
	Patna	-0.14		
	Mahuva	-0.14		
	Chennai	-0.12		
Pune	Pune	0.98	Indore	0.18
	Lasalgaon	0.35	Lasalgaon	-0.18
	Mumbai	0.20	Mahuva	-0.16
	Chennai	-0.16	Solapur	0.14
	Indore	-0.14	Kolkata	0.12
Solapur	Solapur	0.95	Mahuva	-0.17
	Lasalgaon	0.19	Indore	0.13
	Bangalore	0.17		
	Indore	-0.17		
	Patna	-0.12		
	Chennai	-0.10		

Note: The coefficients are significant at 5 per cent level of significance.

Expansion of geographical diversification and distribution of the crop in newer pockets would help in minimising the impact of production uncertainties. The instability in production can be reduced by diluting regional concentration of onion production. Saxena and Chand (16) suggested that the interventions in terms of onion cultivation and technology by extending its cultivation beyond present seasons may really be useful and the suitable varieties need to be developed to suit various agro-climatic conditions so that the

seasonal span of the onion crop can be expanded or adjusted to have continuous supply in the markets.

As the onion production concentrates in fewer states, so does the market power. Markets in the leading state i.e., Maharashtra, are pre-dominant in terms of onion supply and distribution and thereby creating strong influences on other markets. Within Maharashtra, Lasalgaon, Pimpalgaon, Solapur and Pune are the major markets transmitting price signals to other major consuming and producing markets. These markets create immediate influence and thus market surveillance is important here. Pimpalgaon and Lasalgaon are the most important primary markets dealing with *rabi* onion. At the same time, Bangalore dominates in terms of *kharif* onion supply and transmits the signals accordingly. In terms of price transmission to consuming markets; Chennai-Bangalore, Delhi-Lasalgaon-Bangalore, Kolkata-Lasalgaon-Bangalore and Mumbai-Lasalgaon are the important interdependent markets which need to be efficiently linked with each other. However, Pimpalgaon emerges as an important market in terms of generating price signals to other producing markets besides Lasalgaon and Bangalore. Thus, market surveillance needs to be given due priority to control for any imperfections and malpractices arising due to advance signals.

In case of contingent and anomalous price situations, stabilisation through stocks by public sector parastatal like NAFED will help reducing the exploitation and market manipulation by private traders. The storage capacity needs to be enhanced at the grass root level. Reliable estimates of storage of onions at disaggregated level are not available in the country; the precise estimates would help in clearly judging the supply estimates and the likely impact on prices. Trade may be an appropriate resort to control the extreme situations, facilitating exports during the price fall situation may help the farmers. The cheap imports from the neighbouring countries may help preventing the crisis situations.

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