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How Price Signals in Pulses are Transmitted across Regions and Value Chain? Examining Horizontal and Vertical Market Price Integration for Major Pulses in India

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Abstract

The paper has applied time series model to investigate the wholesale and retail price market integration of major pulses (tur, gram, moong, urad, masoor) in five major regions namely north zone (NZ), south zone (SZ), east zone (EZ), west zone (WZ) and north east zone (NEZ) in the country based on their volume of production. The study has shown that there exists a strong cointegration among the wholesale as well as retail prices of these major pulses, although the cointegration varies. In addition to the horizontal cointegration, the vertical cointegration between the wholesale and retail prices of different pulses has also been investigated. Different causal relationships have been found between wholesale and retail prices in these five zones. The application of vector error correction model (VECM) has indicated that all the error correction terms (ECTs) are negative and most of these terms are statistically significant, implying that the system once in dis-equilibrium tries to come back to the equilibrium situation. The study has also used Impulse response analysis which shows that change in wholesale prices of these five pulses in one zone will cause change in wholesale prices in other zones. The paper has concluded that price signals are transmitted across regions indicating that price changes in one zone are consistently related to price changes in other zones and are able to influence the prices in other zones. However, the direction and intensity of price changes may be affected by the dynamic linkages between the demand and supply of pulses. The study has provided an interesting insight for policy makers, and for contributing to improve the information precision to predict the price movements used by marketing operators for their strategies and by policy makers for designing the suitable marketing strategies to bring more efficiency across the markets.

Key words: Cointegration, error correction model, Granger causality, impulse response, pulses, stationarity

JEL Classification: Q13

Introduction

In India, the area under pulses is 22-23 million hectares which is 33 per cent of total world area under pulses. During the past few years, the production of pulses has shown an increasing trend, it has increased from 15.77 million tonnes (Mt) in 2010-11 to 17.34 Mt in 2012-13 and further to an all-time high of 19.78 Mt in 2013-14, but declined to 17.38 Mt in 2014-15. In India, the most important pulse crops grown are chickpea (41% of total pulses area), pigeon pea (15%), urd bean (10%), mung bean (9%), cowpea (7%), lentil (5%) and field pea (5%). Across the states, the highest share of pulses came from Madhya Pradesh (27.8 % of total pulse production), followed by Rajasthan (13.7%), Uttar Pradesh (9.13%), Maharashtra (8.6%), Andhra Pradesh (7.18%), Karnataka (7.2%), Chhattisgarh (3.17%) and Jharkhand (3.01%) in 2015-

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16. These states together shared about 80 per cent of the total national pulse production. But this increase has failed to keep pace with the rising consumption demand. India produces 25 per cent of global production but the consumption rate is 27 per cent of global consumption (Mohanty and Satyasai, 2015). The production-consumption trend in the previous decade showed a shortage of 2-3 Mt of pulses annually on an average. Pulses import has increased significantly over the past decade, quantity imported increased from 0.10 Mt in 2000 to 3.9 Mt in 2013-14 (Directorate of Economics and Statistics, Department of Agriculture and Cooperation, 2014-15). The country is the world's largest importer of pulses today. The market price of different pulses necessarily influences the demand for pulses with varying intensity.

It has been argued that market reforms are required for achieving efficient agricultural markets and hence an efficient agricultural production system. Until agricultural markets are integrated, producers and consumers will not be able to realize the potential gains from the common market.

The pulse crops are environment-friendly and improve soil health, besides complementing cereals in both production and consumption. As far as nutrition is concerned, pulses are relatively cheaper source of protein (Joshi and Saxena, 2002). Pulses will form a major source of protein for a huge section of India, particularly for the poor, backward classes and most of the traditionally vegetarian population (Reddy, 2004). In this regard, the prices of pulses play a very important role. As the markets are becoming integrated, the price signals are transmitted across locations and influence prices at other locations. The price mechanism or marketing process of pulses from producer's level to consumer's level involves wholesale market prices and retail market prices. The market integration of pulses has become important due to the interdependence of wholesale and retail markets.

Another important feature is the production-consumption gap which has resulted in a rise in pulse prices, thereby pushing pulses out of the reach of poor household, leading to a negative effect on their nutritional status (Reddy, 2004). Market integration is an important component to ensure remunerative prices to the farmers which will eventually work as an incentive for them to bring more area under pulses. Therefore, the present paper has examined the movement of prices of pulses in spatially separated markets in the country and the transmission of price signals and information across these markets.

The market integration can be measured in terms of strength and speed of price transmission between markets across various regions of a country (Ghafoor *et al*., 2009). The degree, to which consumers and producers can benefit, depends on how domestic markets are integrated with world markets and how the different regional markets are integrated with each other (Varela *et al.*, 2012).

Although, several empirical studies have been done using cointegration techniques which concern the market integration of agricultural commodities in India (Reddy *et al.,* 2012; Bhardwaj *et al*., 2015; Wani *et al*., 2015a; 2015b; 2015c; Saxena *et al*., 2015; Paul *et al*., 2015; Paul and Sinha, 2015), a little work has been carried out on empirically evaluating pulses market integration in India. Also all these studies have been concentrated in finding integration in price of a commodity in different markets, but it is equally important to see market integration between wholesale and retail prices of the commodity, i.e. vertical transmission of information. This study is an attempt to investigate

- Whether the prices of major pulses in different zones of India are co-integrated and influenced by each other?
- What kind of price linkages exist across two stages of pulses value chain, viz. wholesaling and retailing?
- What is the likely influence of changes in prices at one location/stage of value chain on the other location/stage of value chain?

Data and Methodology

The study selected five major pulses (tur, gram, moong, urad and masoor) and five major regions — north zone (NZ), south zone (SZ), east zone (EZ), west zone (WZ) and north-east zone (NEZ) in the country based on the volume of pulses production. Monthly data on retail and wholesale prices of these pulses for the period January, 2009 to July, 2016 (total 91 observations) were collected from the Department of Consumer Affairs, Government of India. The Department monitors the prices of essential commodities based on data collected from 75 market centres spread across the country.

The study has used different statistical methods, namely testing stationarity, concept of cointegration, testing for rank of cointegration, vector error correction model (VECM), Granger causality testing and impulse response function. These techniques allow one to quantify the degree of interconnectedness between the markets. For testing the stationarity of time series data, the tests, namely Augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1979) and Phillips-Perron Unit Root test (Philips and Perron, 1988) have been applied. The statistical techniques which were used in the present investigation are described below in brief.

Johansen Approach

Johansen (1988) multivariate cointegration approach was used to examine cointegration among price series. When the data are non-stationary purely due to unit roots (integrated once, denoted by I(1)), they could be brought back to stationarity by differencing. If a series must be differenced d-times before it becomes stationary, then it contains 'd' unit roots and is said to be integrated of order d, denoted by I(d). Let $\mathbf{y_t}$ be and n×1 set of I(1) variables. In general, any linear combination $\boldsymbol{\alpha}_i'\mathbf{y_t}$ will also be I(1) for arbitrary $\mathbf{a \neq 0}$. However, suppose there exists an n×1 vector $\boldsymbol{\alpha}_i$ such that $\boldsymbol{\alpha}_i'\mathbf{y_t}$, then it is said that the variables in $\mathbf{y_t}$ are cointegrated of order one, denoted CI(1) and $\boldsymbol{\alpha}_i$ is a cointegrating vector. It is to be mentioned that if $\boldsymbol{\alpha}_i$ is a cointegrating vectors then so is the k$\boldsymbol{\alpha}_i$ for any k≠0 since $k\boldsymbol{\alpha}_i'\mathbf{y_t} \sim \mathbf{I(0)}$.

There can be r different cointegrating vectors, where $0 \leq r < n$, i.e. r must be less than the number of variables n. In such a case, we can distinguish between long-run relationships between the variables contained in $\mathbf{y_t}$, that is, the manner in which the variables drift upward together, and the short-run dynamics, that is the relationship between deviations of each variable from their corresponding long-run trend.

Granger Causality Tests

Granger causality provides additional evidence as to whether and in which direction price transmission has occurred between two series (Granger, 1980; 1988). Historically, Granger (1969) and Sims (1972) were the ones who formalized the application of causality in economics. We investigate the Granger causality tests by fitting VAR and VECM models for our data series in order to identify the direction of causality among the prices.

Error Correction Models (ECM)

In vector and matrix notation, the ECM can be written as per Equation (1)

$$\mathbf{\Delta y_t = \alpha\beta' y_{t-1} + \Gamma_1 \Delta y_{t-1} + u_i} \qquad \ldots(1)$$

where, $\boldsymbol{\alpha}=[\alpha_1, \alpha_2]'$, $\boldsymbol{\beta}'=[1, -\beta_1]$ and, $\Gamma_1 = \begin{bmatrix} \gamma_{11} & \gamma_{12} \\ \gamma_{21} & \gamma_{22} \end{bmatrix}$

Equation (1) can be reformulated into a vector error correction model (VECM) (Equation 2):

$$\Delta y_t = \Pi y_{t-1} + \sum_{j=1}^{k-1} \Gamma_j \Delta y_{t-j} + u_t, \ \ t = k+1, ..., \Gamma \qquad \ldots(2)$$

where, $\Gamma_i = -(A_{i+1} + ... + A_k)$, i=1,…,k-1, and

$\Pi = -(I - A_1 - ... - A_k)$. This way of specifying the system contains information on both the short-run and long-run adjustments to changes in $\mathbf{y_t}$, via the estimates of $\hat{\Gamma}_i$ and $\hat{\Pi}$, respectively. $\Pi = \alpha\beta'$, where α represents the rate of adjustments to disequilibrium and β is a matrix of long-run coefficients such that the term $\beta' y_{t-1}$ embedded in Equation (2)represents up to (n-1) cointegration relationships in the multivariate model.

Thus, we have examined the relationship between the price series by using the IRF (impulse response function). The IRF is a useful instrument used to predict the effect of a shock on a specific series.

Results and Discussion

Before cointegration analysis, the price series were investigated in terms of descriptive statistics and the same are reported in Table 1. It has been revealed that the wholesale and retail prices were more volatile in tur and urad pulses in terms of coefficient of variation (CV). While investigating market integration, the first step is to check for the evidence of non-stationarity of data in order to confirm that cointegration approach is the appropriate method. This analysis was performed by using ADF test and PP test. The results of ADF test and PP tests revealed that all the variables were non-stationary at level. It indicates that series has time-dependent statistical properties which may be stochastic or deterministic. To check stationarity, the series were differenced to first order which became stationary after first differencing. The data became stationary series which had a constant mean and a

Table1. Descriptive statistics for wholesale and retail prices of individual pulses in different zones of India

Statistics	Wholesale price					Retail price				
	North Zone	South Zone	East Zone	West Zone	North-East Zone	North Zone	South Zone	East Zone	West Zone	North-East Zone
					Gram					
Mean	43.87	48.42	43.11	42.37	45.34	49.15	52.74	47.13	46.86	49.76
Median	43.02	48.80	41.33	42.29	44.00	48.53	53.08	45.11	46.88	48.25
Maximum	89.88	94.04	92.87	89.96	84.67	97.96	99.92	97.93	96.52	91.00
Minimum	26.75	26.00	26.83	26.00	30.00	31.88	32.17	31.00	28.80	32.00
Std. Dev.	12.85	14.42	13.20	13.45	12.42	13.22	14.30	13.93	13.92	12.82
CV(%)	29.29	29.78	30.62	31.75	27.38	26.90	27.11	29.56	29.70	25.76
					Masoor					
Mean	57.52	56.30	53.56	52.00	60.01	62.75	60.87	57.97	57.11	66.55
Median	54.90	51.50	51.00	48.34	56.63	60.00	56.78	55.63	51.90	63.40
Maximum	92.08	85.39	84.67	80.16	94.00	99.80	91.36	88.89	87.08	99.50
Minimum	39.00	41.50	36.50	36.42	36.75	44.38	47.00	41.00	42.88	42.00
Std. Dev.	13.72	12.02	13.11	12.70	14.69	14.31	12.65	13.27	12.60	14.41
CV(%)	23.85	21.36	24.48	24.42	24.47	22.80	20.79	22.88	22.06	21.65
					Moong					
Mean	71.89	75.93	70.98	69.04	72.72	77.98	80.25	76.17	74.39	79.10
Median	70.25	72.25	69.50	64.23	70.67	76.14	76.00	74.33	69.44	75.80
Maximum	106.96	108.66	106.00	98.73	102.00	116.60	116.00	110.80	103.58	113.50
Minimum	38.00	43.50	40.00	39.00	42.00	44.86	45.00	43.67	41.60	46.00
Std. Dev.	14.89	16.39	15.13	15.53	14.91	15.98	17.27	16.26	15.74	16.65
CV(%)	20.72	21.58	21.32	22.50	20.51	20.49	21.52	21.34	21.15	21.05
					Tur					
Mean	73.28	76.26	70.04	70.39	66.85	78.56	80.73	74.44	75.85	71.29
Median	65.33	68.00	62.25	63.13	59.38	70.71	72.25	66.50	68.38	63.75
Maximum	144.00	164.53	147.00	134.09	132.67	157.43	172.91	151.80	141.83	147.67
Minimum	46.00	44.00	47.00	49.00	45.00	47.44	48.00	43.25	46.20	43.00
Std. Dev.	24.49	26.48	23.87	22.84	22.11	26.50	27.64	25.50	23.78	23.44
CV(%)	33.42	34.72	34.08	32.44	33.08	33.73	34.24	34.25	31.35	32.88
					Urad					
Mean	66.41	77.33	65.03	65.30	70.05	72.26	81.92	69.73	70.37	75.02
Median	57.72	65.98	56.71	55.38	63.00	63.10	69.00	61.14	60.88	69.00
Maximum	132.15	164.04	136.07	141.42	151.67	144.52	172.19	144.27	150.59	158.33
Minimum	36.50	34.00	33.00	30.00	35.00	43.29	44.25	37.00	39.40	44.80
Std. Dev.	23.13	30.95	24.56	26.61	22.42	24.53	31.83	26.00	27.45	23.50
CV(%)	34.83	40.03	37.76	40.75	32.01	33.95	38.85	37.28	39.01	31.32

constant finite covariance structure. So the series did not vary systematically with time, but tended to return frequently to its mean value and fluctuated around it within a more or less constant range. It indicated that the data set was suitable for cointegration.

Cointegration in Price Series

To check for cointegration among wholesale prices of individual pulses in different zones, Johansen method of cointegration was applied. The results of Johansen's cointegration test for wholesale and retail prices are presented in Table 2 using the trace statistic. The use of maximum eigen value statistic has also resulted in the same conclusion as that of trace statistic. Therefore, the results of maximum eigen value statistic are not reported. It is indicated that across wholesale and retail prices of gram in different zones, there was one cointegrating relationship; in masoor, there was no cointegrating relationship among the wholesale price, whereas in retail price there was one cointegrating relation; in moong retail price, there were 3 cointegrating relations whereas in wholesale price two stationary relationships existed; in tur wholesale as well as retail price, there were 4 cointegrating relationships; in urad wholesale price, two stationary relations existed and in retail price there was one cointegrating relationship.

Table 2. Cointegration among different zones with respect to wholesale and retail prices of pulses

No. of cointegrating equations	Wholesale prices				Retail prices			
	Eigen value	Trace statistic	5% Critical value	Probability	Eigen value	Trace statistic	5% Critical value	Probability
				Gram				
None	0.329	84.141	69.818	0.003	0.312	75.974	69.819	0.015
At most 1	0.224	47.032	47.856	0.059	0.188	43.182	47.857	0.129
At most 2	0.161	26.706	29.797	0.109	0.149	24.904	29.798	0.165
At most 3	0.114	11.355	15.494	0.191	0.108	10.667	15.495	0.233
At most 4	0.009	0.7959	3.842	0.373	0.008	0.7036	3.842	0.402
				Masoor				
None	0.278	67.775	69.819	0.072	0.321	75.494	69.819	0.017
At most 1	0.190	39.157	47.856	0.254	0.195	41.443	47.857	0.175
At most 2	0.122	20.651	29.797	0.380	0.153	22.423	29.798	0.276
At most 3	0.094	9.189	15.495	0.348	0.084	7.833	15.495	0.484
At most 4	0.005	0.454	3.841	0.501	0.003	0.207	3.842	0.650
				Moong				
None	0.312	83.653	69.819	0.003	0.363	106.556	69.819	0.000
At most 1	0.268	50.774	47.856	0.026	0.296	66.885	47.856	0.000
At most 2	0.141	23.354	29.797	0.229	0.192	36.057	29.797	0.008
At most 3	0.082	9.955	15.495	0.284	0.136	15.327	15.495	0.052
At most 4	0.028	2.462	3.841	0.117	0.049	3.440	3.841	0.055
				Tur				
None	0.439	129.935	69.819	0.000	0.381	132.320	69.819	0.000
At most 1	0.318	79.002	47.856	0.000	0.372	90.047	47.856	0.000
At most 2	0.228	45.295	29.797	0.000	0.291	49.042	29.797	0.000
At most 3	0.217	22.532	15.495	0.004	0.192	18.818	15.495	0.015
At most 4	0.011	0.989	3.841	0.320	0.000	0.005	3.841	0.942
				Urad				
None	0.449	103.801	69.819	0.000	0.352	83.062	69.819	0.003
At most 1	0.236	51.326	47.856	0.023	0.206	44.835	47.856	0.094
At most 2	0.169	27.595	29.797	0.088	0.183	24.512	29.797	0.180
At most 3	0.084	11.261	15.495	0.196	0.062	6.715	15.495	0.611
At most 4	0.039	3.495	3.841	0.062	0.012	1.086	3.841	0.297

Source: Authors' estimation

In addition to the horizontal cointegration, the vertical cointegration between the wholesale and retail prices of different pulses were also investigated. The results of Johansen's cointegration test are presented in Table 3 using the trace statistics. In gram, there was a significant vertical cointegration among wholesale and retail prices only in East and West zones; in masoor, the wholesale and retail prices were cointegrated in East, North and North-East zones; for moong, in EZ, NZ and NEZ the wholesale and retail prices were

Table 3. Zone-wise cointegration between wholesale and retail prices of individual pulses

No. of cointegrating equations	Eigen value	Trace statistic	5% critical value	Probability	Eigen value	Trace statistic	5% critical value	Probability
		Gram: East zone				**Gram: North-East zone**		
None	0.279	28.837	15.495	0.000	0.121	11.340	15.495	0.191
At most 1	0.001	0.087	3.841	0.768	0.000	0.007	3.841	0.931
		Gram: North zone				**Gram: South zone**		
None	0.140	14.491	15.495	0.070	0.075	6.898	15.495	0.590
At most 1	0.013	1.188	3.841	0.276	0.000	0.000	3.841	0.991
		Gram: West zone				**Masoor: North zone**		
None	0.218	22.310	15.495	0.004	0.275	28.402	15.495	0.000
At most 1	0.008	0.698	3.841	0.403	0.001	0.114	3.841	0.735
		Masoor: South zone				**Masoor: West zone**		
None	0.146	14.279	15.495	0.076	0.171	16.554	15.495	0.035
At most 1	0.004	0.377	3.841	0.539	0.000	0.002	3.841	0.965
		Masoor: East zone				**Masoor: North-East zone**		
None	0.279	28.837	15.495	0.000	0.121	11.340	15.495	0.191
At most 1	0.001	0.087	3.841	0.768	0.000	0.007	3.841	0.931
		Moong: East zone				**Moong: North-East zone**		
None	0.200	22.868	15.495	0.003	0.209	22.387	15.495	0.004
At most 1	0.036	3.253	3.841	0.071	0.020	1.778	3.841	0.182
		Moong: North zone				**Moong: South zone**		
None	0.305	35.455	15.495	0.000	0.088	11.908	15.495	0.161
At most 1	0.038	3.453	3.841	0.063	0.043	3.825	3.841	0.051
		Moong: West zone				**Tur: East zone**		
None	0.129	15.696	15.495	0.047	0.221	21.968	15.495	0.005
At most 1	0.040	3.558	3.841	0.059	0.000	0.003	3.841	0.953
		Tur: North-East zone				**Tur: North zone**		
None	0.092	9.685	15.495	0.306	0.228	22.920	15.495	0.003
At most 1	0.013	1.165	3.841	0.281	0.002	0.191	3.841	0.662
		Tur: South zone				**Tur: West zone**		
None	0.209	21.742	15.495	0.005	0.305	32.387	15.495	0.000
At most 1	0.013	1.134	3.841	0.287	0.004	0.382	3.841	0.537
		Urad: East zone				**Urad: North-East zone**		
None	0.222	23.598	15.495	0.002	0.433	64.966	15.495	0.000
At most 1	0.017	1.509	3.841	0.219	0.157	15.080	3.841	0.000
		Urad: North zone				**Urad: South zone**		
None	0.460	55.457	15.495	0.000	0.155	14.899	15.495	0.061
At most 1	0.014	1.273	3.841	0.259	0.001	0.079	3.841	0.779
		Urad: West zone						
None	0.321	35.710	15.495	0.000				
At most 1	0.018	1.634	3.841	0.201				

Source: Authors' estimation

cointegrated; for tur, both the prices were cointegrated in all other zones, except in North-East; for urad, in all the zones the prices were vertically cointegrated. The wholesale prices of different pulses were cointegrated in all the zones, except in East zone (Table 4). The cointegrating relations among the wholesale prices were 3 in West zone, one each in North and South zones and 2 in North-East zone.

Causality between Wholesale and Retail Prices of Pulses

The Granger causality helps in establishing the direction of causation (if any) between the variables and thus helps in predicting the value of one variable on the basis of other variable. The basic idea is that variable *X* Granger causes *Y* if past values of *X* can help in explaining *Y*. The null hypotheses of the Granger causality test are: H_0: X does not Granger-cause Y; and H_1: X does Granger-cause Y. The results of pair-wise Granger causality tests were computed but are not reported in the manuscript. If null hypothesis was rejected, then the results were significant. It was concluded that there was no causal relationship between wholesale and retail prices of gram in NEZ, SZ, and WZ; of masoor in NEZ; of moong in NZ; of tur in EZ; and of urad in NZ and SZ. It was found that the wholesale price Granger causes the retail price for gram in East and North-East zones; for masoor in East, North, South, and West zones; for moong in North-East and West zones; for tur in North-East, North, South and West zones; for urad in East zone. For moong, the causal relationship was reverse in South zone and showed a bi-directional causal relation in East zone. For urad the retail price Granger causes the wholesale price in North-East and West zones.

The acceptance of cointegration between two series implies that there exists a long-run relationship between them and this means that an error-correction model (ECM) is applicable, which combines the long-run relationship with the short-run dynamics of the model. Therefore, after confirming cointegration in wholesale prices of individual pulses across different zones, the error correction term (ECT) was measured and is reported in Table 5. It is indicated that all the ECTs

Table 4. Cointegration among wholesale prices of pulses in different zones

No. of cointegrating equations	Eigen value	Trace statistic	5% critical value	Probability	Eigen value	Trace statistic	5% critical value	Probability
			East zone				**West zone**	
None	0.273	68.646	69.819	0.062	0.313	92.973	69.819	0.000
At most 1	0.215	40.645	47.856	0.200	0.277	59.954	47.856	0.003
At most 2	0.142	19.375	29.797	0.466	0.196	31.468	29.797	0.032
At most 3	0.061	5.869	15.495	0.711	0.113	12.274	15.495	0.144
At most 4	0.003	0.288	3.841	0.592	0.020	1.759	3.841	0.185
			North zone				**South zone**	
None	0.315	80.112	69.819	0.006	0.311	79.053	69.819	0.008
At most 1	0.237	46.791	47.856	0.063	0.215	46.325	47.856	0.069
At most 2	0.136	23.045	29.797	0.244	0.141	25.016	29.797	0.161
At most 3	0.102	10.149	15.495	0.269	0.111	11.649	15.495	0.175
At most 4	0.007	0.634	3.841	0.426	0.014	1.253	3.841	0.263
			North-East zone					
None	0.555	120.324	69.819	0.000				
At most 1	0.228	49.058	47.856	0.038				
At most 2	0.183	26.261	29.797	0.121				
At most 3	0.084	8.437	15.495	0.420				
At most 4	0.008	0.688	3.841	0.407				

Source: Authors' estimation

Table 5. Rate of adjustment as measured by error correction term (ECT) in VECM

Market pairs		Ist variable	2nd variable	Ist variable	2nd variable	Ist variable	2nd variable
		Gram		**Masoor**		**Moong**	
EZ	NZ	-0.087	-0.317**	-0.512**	-0.042**	0.035	-0.300**
EZ	SZ	-0.084	-0.278*	-0.168*	-0.126*	-0.193*	-0.142*
EZ	WZ	-0.002	-0.340**	-0.123	-0.194*	-0.069	-0.391**
EZ	NEZ	-0.448**	-0.210*	-0.189**	-0.299**	-0.209**	-0.422**
NZ	SZ	-0.082	-0.383**	-0.168**	-0.126**	-0.578**	-0.120*
NZ	WZ	0.846**	-0.515**	-0.123	-0.194*	-0.282**	-0.003
SZ	WZ	-0.306**	-0.063	-0.112**	-0.012	-0.047	-0.265**
NEZ	NZ	-0.131	-0.581**	-0.374**	-0.151**	-0.032	-0.319**
NEZ	SZ	-0.148*	-0.486**	-0.236**	-0.156**	-0.475**	-0.058
NEZ	WZ	-0.714**	-0.524**	-0.185**	-0.045	-0.193**	-0.279**
		Tur		**Urad**			
EZ	NZ	-0.158*	-0.504**	-0.015	-0.264*		
EZ	SZ	-0.126*	-0.327**	-0.400**	-0.257**		
EZ	WZ	-0.219**	-0.334**	-0.036	-0.230**		
EZ	NEZ	-0.232**	-0.317**	-0.070	-0.457**		
NZ	SZ	-0.525**	-0.199*	-0.283**	-0.190*		
NZ	WZ	-0.871**	-0.299**	-0.114*	-0.118*		
SZ	WZ	-0.321**	-0.376**	-0.144*	-0.176**		
NEZ	NZ	-0.163**	-0.574**	-0.355**	-0.032		
NEZ	SZ	-0.141**	-0.220**	-0.806**	-0.592**		
NEZ	WZ	-0.222**	-0.376**	-0.380**	-0.031		

Note: * and ** show significance at 5 per cent and 1 per cent level respectively
Source: Authors' estimation

were negative and most of these terms were statistically significant, implying that the system once in dis-equilibrium, tries to come back to the equilibrium situation. For fitting of VECM model, first an unrestricted VAR model was fitted and optimum lag was determined based on sequential modified Likelihood ratio test statistic, Final prediction error (FPE), Akaike information criterion (AIC), Schwarz information criterion (SIC) and Hannan-Quinn information criterion (HQIC). After selecting the optimum lag, VECM model was fitted with that lag to determine the ECT. The higher the value of ECT, the higher is the rate of adjustment towards equilibrium.

The way of interaction, as resulted from pair-wise Granger causality testing is depicted in Figure 1. It clearly indicates how different zones interact among themselves regarding wholesale price information flow for different pulses.

We investigated the effect of a positive shock to an individual price on another endogenous variable by performing impulse response analysis, which could be used to show the magnitude and lasting effects. Figure 2A represents the IRF results for the wholesale prices of gram. Figure 2A(1) shows that changes in wholesale prices of gram in West zone will cause increases in wholesale prices of gram in East zone in the first six months and will decrease thereafter. However, an increase in wholesale prices of gram in West zone will lead to an increase in the wholesale prices of gram in North-East zone. Similar effect can be found in South and North zones.

Figure 2B presents the IRF results for wholesale prices of moong. It appears that changes in wholesale prices of moong in West zone will cause an increase in wholesale prices of moong in East zone at least up to 10 months. However, an increase in wholesale prices

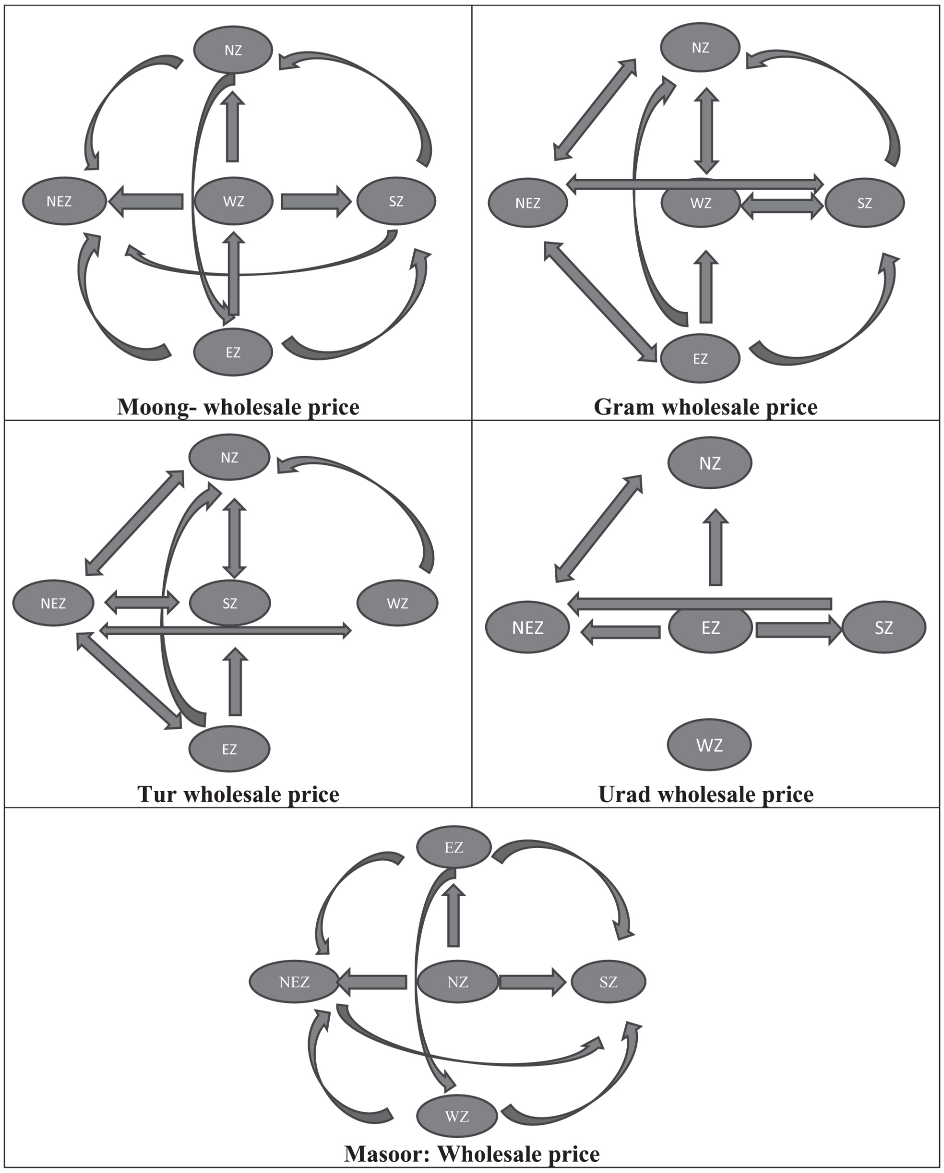

Figure 1. Direction of price causation in major pulses of India

of moong in West zone will not change anything to the wholesale prices of moong in North-East zone up to two months and then lead to increase it. A similar effect can be seen in South zone. Interestingly, in North zone, price decreases due to increase in wholesale prices of moong in West zone [Figure 2B(3)].

Figure 2C presents the IRF results for wholesale prices of masoor. From Figure 2C(1), it appears that changes in wholesale prices of masoor in North zone will cause an increases in wholesale prices of moong in East zone up to two months and then it will decrease up to seven months and then will become stagnant. However, an increase in wholesale prices of masoor in North zone will lead to increase the wholesale prices of masoor in North-East zone up to eight months and then would become stagnant. In South zone, the price increased up to two months due to increase in wholesale prices of masoor in North zone and then became almost stable. In West zone, the price had a rapid increase in first three months and then there was a slight decrease up to ten months [Figure 2C(4)].

Figure 2D presents the IRF results for wholesale prices of tur. In Figure 2D(1), it appears that changes in wholesale prices of tur in South zone will cause an

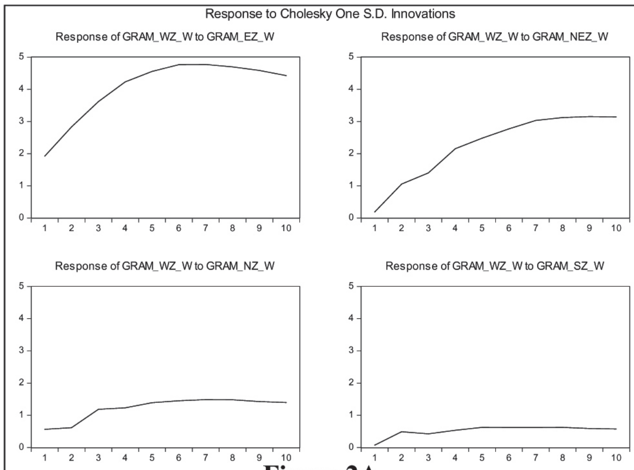

Figure 2A

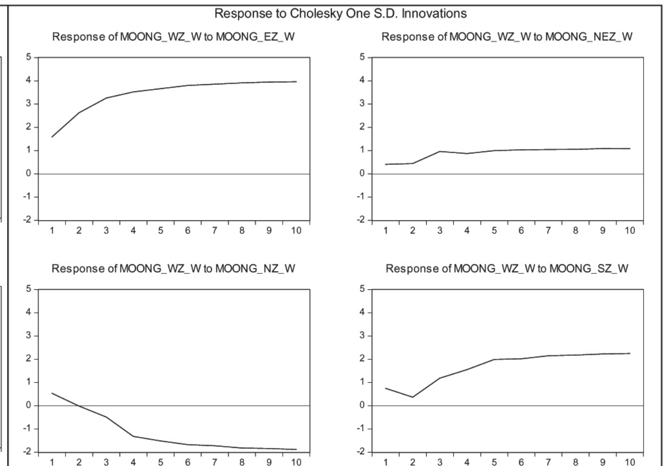

Figure 2B

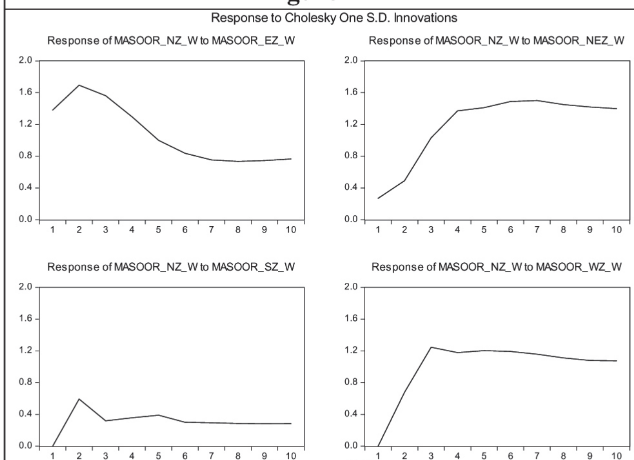

Figure 2C

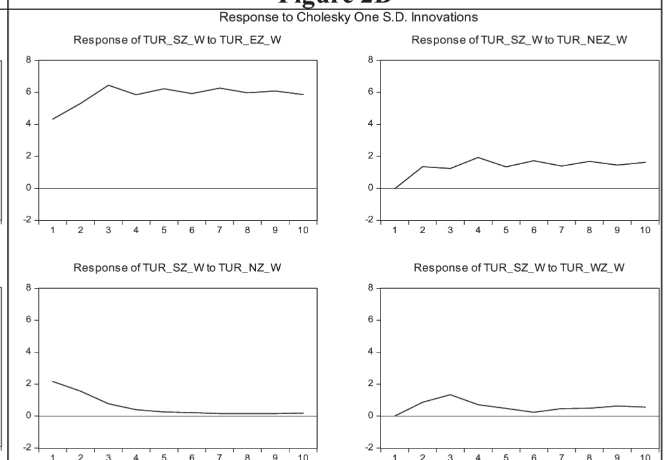

Figure 2D

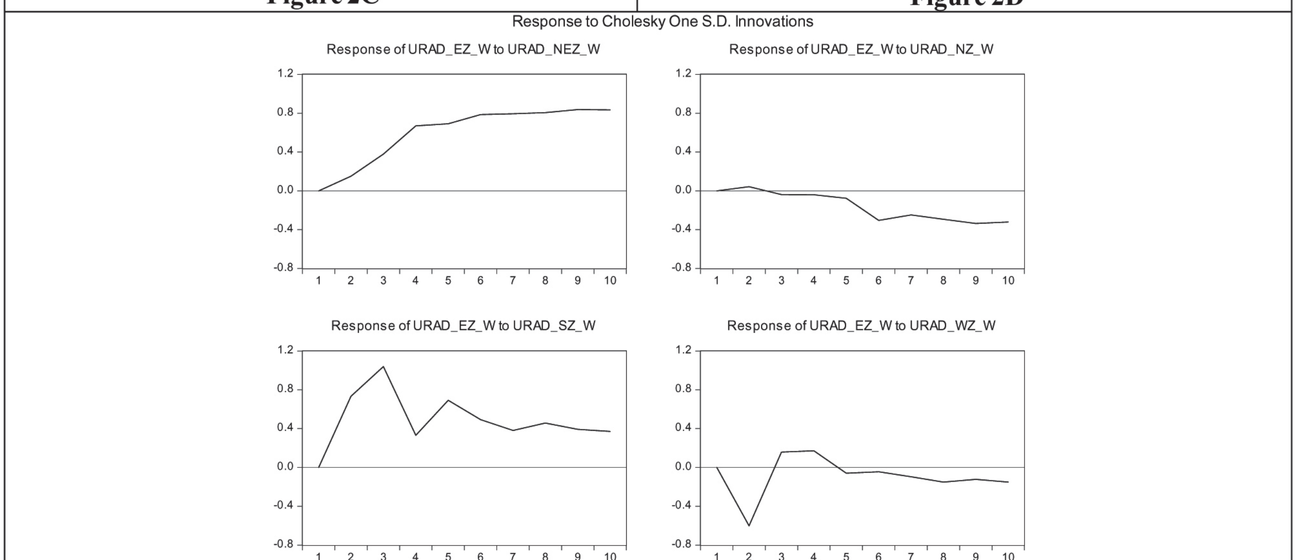

Figure 2E

Figure 2. Response of change in wholesale price of different pulses in one zone to the other zones

increase in wholesale prices of tur in East zone up to three months and then would become stagnant. However, an increase in wholesale prices of tur in South zone will increase the wholesale prices of tur in North-East zone in first month followed by decrease in the next month and alternatively this phenomenon is repeated. In North zone, price will decrease up to five months due to increase in wholesale prices of tur in South zone and then would become almost stable [Figure 2D(3)]. In West zone, the price would increase in first three months and then would decrease up to six months and will then increase slightly up to ten months [Figure 2D(4)].

Figure 2E presents the IRF results for wholesale prices of urad. In Figure 2E(1), it appears that changes in wholesale prices of urad in East zone will have a steep increase in wholesale prices of urad in North-East zone up to four months and then rate of increase would become slow. However, an increase in wholesale prices of urad in East zone will lead to a decrease in the wholesale prices of urad in North zone after second month [Figure 2D(2)]. In South zone, the price would increase up to three months due to increase in wholesale prices of urad in East zone followed by a decrease and then again increase [Figure 2E(3)]. In West zone, the price decreases in first two months followed by an increase in next month; would become stable and then start decreasing after four months [Figure2E(4)].

Conclusions

The study has focused on time series techniques to test for market integration in wholesale and retail prices of major pulses in India. It has been found that among wholesale and retail prices of gram in different zones, there is one cointegrating relationship; in masoor, there is no cointegrating relationship among the wholesale price, whereas in retail prices there is one cointegrating relation; in moong retail price, there are 3 cointegrating relations, whereas in wholesale price, two stationary relationships exist; in tur wholesale as well as retail prices, there are 4 cointegrating relationships; in urad wholesale price, two stationary relations exist and in retail price, there is one cointegrating relationship. In addition to horizontal cointegration, the vertical cointegration between the wholesale and retail prices of different pulses has also been investigated. The results have revealed that in gram, only in East and West zones there is a significant cointegration among wholesale and retail prices; for masoor, in North, East and West zones the wholesale and retail prices are cointegrated; for moong, in East, North and North-East zones the wholesale and retail prices are cointegrated; for tur, except in North-East zones both the prices are cointegrated in all other zones; for urad, in all the zones the prices are vertically cointegrated. Cointegration among the wholesale prices of pulses in different zones indicates that in all other zones, except in East zone, the wholesale prices of different pulses are cointegrated.

Different causal relationships have been found between wholesale and retail prices in these five zones. The acceptance of cointegration between two series implies that there exists a long-run relationship between them and this means that an error-correction model (ECM) exists which combines the long-run relationship with the short-run dynamics of the model. The results have indicated that all the error correction terms (ECTs) are negative and most of these terms are statistically significant, implying that the system once in disequilibrium tries to come back to the equilibrium situation.

The effect of a positive shock to an individual price on another endogenous variable has been investigated by performing impulse response analysis, which can be used to show the magnitude and lasting effects. Impulse response analysis has shown that changes in wholesale prices of these five pulses in one zone will cause a change in wholesale prices in other zones. It is inferred that the price signals are transmitted across regions indicating that price changes in one zone are consistently related to the price changes in other zones and are able to influence the prices in other zones. However, the direction and intensity of price changes may be affected by the dynamic linkages between the demand and supply of pulses. The insights from the study can be used to improve the information precision to predict the price movements used by marketing operators for their strategies. The policy makers can use it to design suitable marketing strategies to bring more efficiency across the markets.

The pulse prices witnessed tremendous change during the recent period. It has been revealed that most of the markets are co-integrated and rate of adjustments is high when prices are assumed to be influenced by the changes in each other’s price. Thus, it can be inferred that price changes are temporary and would converge to an equilibrium within a given time span. A proper focus on domestic supply management along with international trade coupled with strong market surveillance and intelligence efforts would help control escalating prices and also help in minimizing the distortions widening the gap between the wholesale and retail prices of pulses.

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