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A study of market integration and price transmission amongst the seven major pigeon-pea (*Cajanus cajan*) producing states of India

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ABSTRACT
India has gained self-sufficiency in foodgrains but till today imports pulses to meet its domestic requirements. In 2008-09, the market was hit by supply shock of pigeon pea resulting in vigorous price hike. The present study was undertaken to analyse the decadal (2009-18) monthly wholesale prices of pigeon pea, in the seven highest pigeon pea producing states of India, namely, Madhya Pradesh, Maharashtra, Karnataka, Gujarat, Uttar Pradesh, Jharkhand and Odisha. Time-series analysis of monthly prices indicated that seasonal price index does not follows any particular trend in these states. Pigeon pea being a kharif crop showed high seasonality index (SI) during the lean months and low SI during the harvest season, except for Jharkhand state where SI was highest during December. None of the states out of the seven shared maximum/minimum SI. The coefficient of variation (CV), coefficient of average seasonal price variation (ASPV) and intra-year price rise (IPR) were found to be highest for Karnataka and lowest for Jharkhand. Johansen's cointegration test was used to analyse the existence of linear deterministic trend amongst the seven spatially separated state markets and Granger Causality test was used to determine the price transmission within these states. The maximum likelihood test indicated that three out of the seven states were cointegrated, with majority of the states showing bidirectional movement of prices. Only the state of Odisha showed unidirectional price relationship with other six states.
***Keywords**: Granger Causality, Johansen's cointegration test, India, Price Transmission, Pigeon pea*

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INTRODUCTION

India has attained self-sufficiency in food grains production especially cereals but still depends upon pulses import to feed its ever-growing population; and to keep the retail prices of pulses under check for it to remain within the consumption basket of masses. Pulses import during the year 2016-17(P) was to the tune of 66.09 lakh tonnes valued at Rs.28523.18 crores. This reflects to the extent to which India relies on the import of pulses to meet its feeding requirements. The country's total area coverage and production of pigeon-pea in 2017-18 was about 45 Lakh ha and 42 Lakh tonnes, respectively. Maharashtra was the top pigeon pea producing state in terms of production (25 per cent) and area (27.56 per cent). Highest productivity of pigeon pea was recorded during 2017-18 at 937 kg/ha [8]. It was in 2008-09 that India witnessed the sky-rocketing price of pulses due to the fall in pulse production. It is since then, that the price of pigeon pea have never seen a downfall but have only risen. In today's scenario, the common dal-roti is no more common for the common man. The next step after production of any crop is its efficient marketing. Keeping this situation under consideration, it becomes pertinent to study the market integration and price behaviour of major pulses grown in the country for formulation of suitable polices for higher pulses production and slashing the import burden to some extent. The present study focusses on the marketing aspect of pigeon pea in the top seven pigeon pea growing states on India namely, Madhya Pradesh, Maharashtra, Karnataka, Gujarat, Uttar Pradesh, Jharkhand and Odisha.

MATERIALS AND METHODS

Data source

The study is based on the secondary data collected from the Agmarknet portal [6]. Time series data on wholesale monthly prices of pigeon pea (whole) were collected from January 2009 to December 2018 for seven highest pigeon pea producing states of India viz. Madhya Pradesh, Maharashtra, Karnataka, Gujarat, Uttar Pradesh, Jharkhand and Odisha; which was used for the present analysis.

Analytical techniques

Seasonal indices (SI) were calculated using twelve months ratio to moving average method, to measure seasonal variations in prices. The 12-months moving average is a fairly good estimate of the trend and cyclical components combined. The correction factor was used to make the sum of seasonal indices equal to 1200. The extent of seasonal/ intra-year price variation was estimated using extent of intra year price rise (IPR), coefficient of average seasonal price variation (ASPV) and coefficient of variation (CV) as follows:

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

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

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

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

Market integration

Cointegration test is used to examine the integration between spatially separated commodity markets [1]. Johansen's techniques is considered superior to the methodologies of Hendry and Anderson (1975), Engle and Granger (1987), Goodwin and Schroeder (1991) because of the fact that it allows the testing of cointegration as a system of equation in one step without any prior assumptions of endogenous and exogenous variables [3] [4] [5] [7]. It does not imposes any restrictions on test and therefore an estimation of a number of cointegration relationships can be carried out simultaneously.

Johansen's maximum likelihood test for cointegration:

Correlogram indicates the presence of unit root in the time-series data while it is the Augmented Dickey- Fuller test (ADF) that confirms it. The autoregressive formula used in ADF test was:

$$\Delta p_{it} = a_0 + \gamma p_{it-1} + \sum_{j=2}^{n} \beta_i \, \Delta p_{it-j+1} + \varepsilon_t$$

Where, p_{it} is the price in market i at the time t, $\Delta p_{it} = (p_{it} - p_{it-1})$ and a_0 is the intercept or drift term. The joint hypothesis for checking the presence of unit root is: $H_0: \gamma = a_0 = 0$ using φ1 statistic. Failure of the rejection of null hypothesis means that the series is non-stationary.

In a cointegrated equation system $\Delta Y_t = \sum_{i-1}^{k-1} r_i \Delta Y_{t-1} + \alpha\beta\gamma_{t-k} + \varepsilon_t$, [where, Y_t is the price, ΔY_{t-1} is the first difference operator (Y_t - Y_{t-1}) and matrix $\pi = \alpha\beta$ is (n x n) with rank

r ($0 \leq r \leq n$)] represents the number of linear independent cointegration relations in the vectors of matrix. The Johansen's method of cointegrated system is a maximum likelihood method with restriction on rank of the matrix $\pi = \alpha\beta$. The rank of π can be determined by λ_{trace} test statistics, and is estimated by: $\lambda_{trace} = -T\sum_{i=y+1}^{n}\ln\left(1-\widehat{\lambda_i}\right), for\ r = 0, 1, \dots, n-1$, where, λ_i's are the Eigen values that represent the strength of the correlation between the first difference portion and the error-correction portion.

The following hypotheses were tested, H_0 (null hypothesis): rank of π = r and H_1 (alternate hypothesis): rank of π> r, where 'r' is the number of cointegration equations. The above test was done with the assumption of linear deterministic trend in the original data and just the intercept term in the cointegrating equation. The cointegrating equation has only intercept and no trend because of difference in the price series while testing for its stationarity, whereas; the original price series follows a trend because the mean and variance is not constant over a period of time i.e., non-stationary property. Similarly, bi-variate Johansen's test is used to check the integration between two markets.

Granger causality test for price transmission

After establishing, by the use of Johansen's test, that the markets were co-integrated, Granger causality test (1969) was conducted to find the order and direction of equilibrium relationships [2]. Whether market p_1 Granger causes market p_2 or vice versa was checked using

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

A simple test of the joint significance of δ_k was used to check the Granger causality, i.e.

$$H_0: \delta_1 = \delta_2 = \cdots = \delta_n = 0$$

RESULTS AND DISCUSSION

The figures in table 1 show asymmetric pattern in the pigeon pea prices during the study period with the highest and lowest wholesale prices for the markets of Jharkhand and Madhya Pradesh. All the markets are positively skewed except for the state of Odisha.

Table 1: Descriptive analysis for pigeon pea prices in 7 selected states (n=120)

Parameters	Gujarat	Jharkhand	Karnataka	Madhya Pradesh	Maharashtra	Odisha	Uttar Pradesh
Mean	4225.61	7393.04	5539.51	3869.83	5097.13	5482.76	5032.61
Median	3872.30	6486.14	4885.16	3538.83	4295.22	5571.14	4399.65
Minimum	1950.86	4496.01	3129.87	2232.95	3048.97	1462.84	3357.85
Maximum	8095.61	14149.95	13830.99	7513.04	14071.27	9000.00	9060.59
Std. Dev.	1372.34	2438.43	1994.48	1074.21	1952.86	1300.90	1499.72
Kurtosis	1.58	1.16	3.34	2.10	5.16	0.20	0.77
Skewness	1.46	1.57	1.79	1.47	2.11	-0.16	1.35

Table 2: Trends in prices of pigeon pea in selected states from January, 2009 to December, 2018

States	Coefficients of linear trend
Gujarat	Y= 3395.51 + 13.72x
Jharkhand	Y= 5810.95 + 26.15x
Karnataka	Y= 5227.73 + 5.15 x
Madhya Pradesh	Y = 3142.13 + 12.02x
Maharashtra	Y = 4446.44 + 10.75x
Odisha	Y = 4478.22 + 17.51x
Uttar Pradesh	Y = 4533.37 + 8.25x

Table 2 shows that the pigeon pea prices in all the seven states had a positive and increasing trend during the given time-period.

Table 3: Estimates of selected pigeon pea markets according to IPR, ASPV and CV

States	CV (%)	IPR (%)	ASPV (%)
Gujarat	2.96	12.15	11.46
Jharkhand	3.01	8.96	8.58
Karnataka	3.29	41.12	34.11
Madhya Pradesh	2.53	17.64	16.21
Maharashtra	3.50	19.85	18.06
Odisha	2.26	14.66	13.66
Uttar Pradesh	2.72	13.98	13.07

Table 3 shows the intra-year price rise (IPR) for pigeon pea over a decade for the country's top pigeon pea producing states i.e., from 8.96 in Jharkhand to 41.12 in Karnataka. The values of average seasonal price variation (ASPV) ranged between 8.58 in Jharkhand to 34.11 in Karnataka. The IPR and ASPV tend to affect the pricing decisions of annual crop production. The coefficient of variation for pigeon pea prices varied between 2.26 for Odisha to 3.50 in Maharashtra.

Table 4: Seasonal index

Months	Gujarat	Jharkhand	Karnataka	Madhya Pradesh	Maharashtra	Odisha	Uttar Pradesh
January	101.78	100.96	115.30	101.25	96.57	99.80	102.57
February	100.41	99.50	119.41	101.44	92.78	96.21	93.75
March	99.81	97.75	103.60	100.06	92.48	94.10	96.15
April	103.72	94.60	91.16	102.90	98.96	101.07	101.71
May	103.05	98.20	84.61	99.94	99.38	98.88	102.22
June	104.23	99.18	88.95	108.33	94.37	100.43	100.92
July	101.23	100.62	92.29	99.24	97.94	100.93	101.68
August	102.45	100.57	95.54	102.13	106.79	94.28	106.85
September	99.28	101.72	98.67	99.60	102.33	107.90	100.19
October	92.94	101.29	98.40	96.55	108.48	101.68	100.68
November	93.10	102.55	102.80	92.08	110.84	96.88	97.62
December	98.00	103.08	109.27	96.48	99.08	107.85	95.68

In table 4, decomposition of prices revealed that there is no common trend in the seasonal price index among these states. As expected, pigeon pea being a kharif crop showed high seasonality index (SI) during the non-harvest period, except in Jharkhand, where the SI was highest during December, but no two states shared common months for highest or lowest Seasonal Index.

Table 5: Estimates of Augmented Dickey Fuller (ADF) test for the monthly prices

States	ADF statistic for testing unit root		Order
	Level series	1st differenced series	
Gujarat	-2.61	-10.18*	I(1)
Jharkhand	-2.01	-4.99*	I(1)
Karnataka	-2.97	-7.68*	I(1)
Madhya Pradesh	-2.39	-11.08*	I(1)
Maharashtra	-2.39	-7.65*	I(1)
Odisha	-5.02	-13.01*	I(1)
Uttar Pradesh	-1.47	12.92*	I(1)

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

Table 5 shows that the original series was non-stationary and non-significant, but the 1st differentiated series turned out to be stationary and is significant at one per cent level.

Table 6: Estimates of Johansen's multiple cointegration test

Markets	Lag length (AIC Value)	H_0: rank= r	Eigen value	Trace statistic	Max Eigen statistic
Gujarat Jharkhand Karnataka Madhya Pradesh Maharashtra Odisha Uttar Pradesh	4	r = 0*	0.398505	159.8847	49.81706
		r ≤ 1*	0.318767	110.0676	37.61743
		r ≤ 2*	0.290726	72.45020	33.66437
		r ≤ 3	0.227216	38.78584	25.26000
		r ≤ 4	0.83516	13.52583	8.546617
		r ≤ 5	0.46502	4.979215	4.666586
		r ≤ 6	0.003185	0.312629	0.312629

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

Table 6 showed that the actual values are more than the critical values leading to the rejection of null hypothesis at 0.05 level, indicating the presence of some cointegration in three out of seven markets.

Table 7: Price transmission between markets by Granger causality test

States	Gujarat	Jharkhand	Karnataka	Madhya Pradesh	Maharashtra	Odisha	Uttar Pradesh
Gujarat		↔	→	↔	↔	→	↔
Jharkhand	↔		X	↔	↔	→	X
Karnataka	X	→		↔	X	→	↔
Madhya Pradesh	↔	↔	↔		↔	→	↔
Maharashtra	↔	↔	X	↔		→	↔
Odisha	X	X	X	X	X		X
Uttar Pradesh	↔	X	↔	↔	↔	X	

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

Table 7 shows that the state of Odisha has only unidirectional price relationship with other states i.e., the prices of pigeon pea in Odisha are affected by the pigeon pea prices of other states but in turn it does not affects their pricing behaviour. Gujarat has bidirectional influence with Jharkhand, Madhya Pradesh, Maharashtra and Uttar Pradesh. Karnataka affects the pricing behaviour of Jharkhand but in turn is affected by Gujarat. Jharkhand has bidirectional relationship with Madhya Pradesh, Maharashtra while Karnataka has bidirectional influence on Madhya Pradesh and Uttar Pradesh. Madhya Pradesh has bidirectional influence on all the states except for Odisha with which it has unidirectional relationship.

CONCLUSIONS

- It was found that the wholesale prices of pigeon pea had asymmetric pattern during the study period with the highest and lowest wholesale prices for the state markets of Jharkhand and Madhya Pradesh, respectively.
- The original time-series data for wholesale prices was found to be non-stationary and non-significant, but the 1st differentiated series turned out to be stationary and significant at one per cent level.
- Johansen's multiple cointegration test has indicated the presence of spatial integration amongst three states out of the seven states.
- Majority of the states have shown bidirectional price transmission and few have shown unidirectional/ no price movements. Odisha is the only state which has indicated unidirectional flow of pigeon pea prices from other states.
- Hence, these indicate improved spatial integration amongst three state markets and better price transmissions between the seven states for pigeon pea. Spatial market integration and price transmission between the wholesale state markets can be made more efficient by formulating and implementing marketing policies for the pigeon pea crop.
- Major pricing policy reforms regarding production, marketing and export-import coupled with procurement facilities are required to bring stability in the prices of pigeon pea so that the farmers may receive remunerative prices. This will in turn lead to increased production and self-sufficiency in pigeon pea in the long run.

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