J. Farm Sci., 34(4): (422-426) 2021

RESEARCH PAPER

Co - integration of soybean markets in India - An econometric analysis

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(*Received: October, 2021 ; Accepted: November, 2021*)

Abstract: The present study was undertaken to analyze soybean market integration in six major regional markets located in Madhya Pradesh (Dewas and Ujjain), Maharashtra (Amravati and Latur) and Karnataka (Bidar and Dharwad) states of India, using monthly wholesale prices of soybean during 2005 to 2020. Augmented Dickey-Fuller Unit root test indicated that the price series in each location are non-stationary at their levels, and stationary at their first differences. Co-integration results showed that the regional markets have price linkages and thus are spatially integrated. Johansen's multiple co-integration tests reveals that that their existence of only two co-integration equations for selected soybean markets based on likelihood-ratio test. Granger causality test explain that, Dewas market prices of Madhya Pradesh will have influence on Maharashtra and Karnataka soybean commodity markets price, Its clearly manifest to be independent market for soybean prices in south India and also the bidirectional relationships don't exist within domestic markets, but there in Bidar and Amravati markets evidencing the interstate price influence of proximities, which indicated the price transmission happening in long run adjustments and the presence of short run equilibrium existed among the soybean markets in India. Vector error correction estimates indicates that, extent of soybean markets integration for different lags in the current study.

Key words: Granger causality test, Independent market, Price transmission, Unit root test

Introduction

Soybean is known as 'Golden bean', whereas Madhya Pradesh is called as soy bowl of the country because of maximum share in production. It's a legume crop but widely used as oilseed. Second largest oilseed produced in India after groundnut. Important commercial crop in many countries, such as Japan, China, Indonesia, Philippines and European countries are importing Soybean to supplement their domestic requirement for human consumption and cattle feed.

Soybean has an important place in world's oilseed cultivation scenario, due to its high productivity, profitability and vital part towards maintaining soil fertility. The crop also has a prominent place as the world's most important seed legume, which contributes 25 % to the global vegetable oil production, about two thirds of the world's protein concentrate for livestock feeding and is a valuable ingredient in formulated feeds for poultry and fish. About 85 % of the world's soybeans are processed annually into soybean meal and oil. Approximately 98 % of the soybean meal is crushed and further processed into animal feed with the balance used to make soy flour and proteins. Of the oil fraction, 95 % is consumed as edible oil; the rest is used for industrial products such as fatty acids, soaps and biodiesel. The major soybean producing nations are the United States, Brazil and Argentina. The three countries dominate global production, accounting for 80 % of the world's soybean supply (Anon., 2020).

India stands 4th position in the list of the leading soybean producing countries with a production of around 12.9 million tons. Regarding consumption of soybean in India (FAO Stat. 2020), it holds the fourth position in the leading consuming countries. In India, 10-12 % of it is directly consumed and the rest is crushed to derive soy meal and soy oil. The prices of soybean in the Indian market are highly volatile because they depend on the prices of the international market.

Madhya Pradesh, Maharashtra, Rajasthan, Karnataka and Telangana are the major cultivators of this important oilseed, with their respective contributions usually around 55 lakh ha, 40 lakh ha, 10.6 lakh ha,3.3 lakh ha and 1.77 lakh ha in total countries production (Indiastat., 2020). Soybean is exclusively grown in the *kharif* season in India, with sowing taking place after the first monsoon showers in late June or early July. Sowing can extend up to end of July in different parts of the country. The harvesting commences from September, with Maharashtra reporting the earliest arrivals. October and November are the peak arrival months. Soybean has largely been responsible in uplifting farmer's economic status in many pockets of the country. It usually fetches higher income to the farmers owing to the huge export market for soybean de-oiled cake.

Markets are said to be integrated when groups of goods move proportionally to each other. When this relationship is particularly apparent among diverse markets, the markets are said to be integrated. If the markets 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.

Oilseed cultivation in India is undertaken mainly in high-risk areas with uncertain returns on investment. In the past, little attention was paid to managing production, marketing and price risks in oilseed cultivation. The present crisis must be altered. The importance of risk categorization and identification of essential risks along the supply chain has become increasingly apparent as stakeholders understand that

successful risk management in production and marketing is critical for farmer's to continue production of oilseeds.

Materials and methods

This study was carried out in throughout the country with special reference to Karnataka, considering major soybean markets among different states based on secondary data collected from Agmarknet and Krushimaratavahini during 2019-20. Two major soybean markets were identified based on major arrivals among the different soybean producing states in the country.

Selection of markets

In India, Madhya Pradesh, Maharashtra and Karnataka put together contributes more than 90 per cent of the country's total soybean production, so markets from the above states were selected purposively. The study is based on monthly wholesale price data for six major soybean markets namely, Dewas, Ujjain, Amravati, Latur, Bidar and Dharwad markets for the period from January 2005 to December 2020 were analysed.

Market integration

Prices in spatially integrated markets are determined simultaneously in various locations, and information of any change in price in one market is transmitted to other markets [Gonzalez-Rivera and Helfand (2001)]. Markets that are not integrated may convey inaccurate price signal that might distort producers marketing decisions and contribute to inefficient product movement and traders may exploit the market and benefit at the cost of producers and consumers.

Price transmission analysis

The output of price transmission analysis helps to understand the following points - Is there a long-term relationship between the two markets, Do prices in market 'A' influence those in market 'B', the reverse, or do they both influence each other, If the price in one market changes how much will it cause the other price to change in short run and if the price in one market changes how much will it cause the other price to change in the long run (Rivera, 2007). In the context of two domestic prices, it tells us whether market 'A' is influencing market 'B', or 'B' is influencing 'A', or if both are influencing each other. This causation analysis helps in understanding and describing trends in local prices.

ADF test

Prior to testing for co-integration, the price series are first tested for their order of integration, since a necessary condition for co integration is that the series are integrated of the same order. The augmented Dickey- Fuller (ADF) test is used to test for the order of integration. To test unit root, the ADF test is conducted based on the following regression equation:

$$\Delta Y_t = \beta_1 + \delta Y_{t-1} + \alpha_i \Sigma \Delta Y_{t-1} + e_t$$

[t-1: 1 month lagged price and Δ: differenced series]

Y_i denoted the price series of markets (Dewas, Ujjain, Amaravati, Latur, Bidar and Dharwad soybean price series).

Engle-granger causality

An autoregressive distributed lag (ADL) model for the Granger-causality test was developed following Engle and Granger (1987) specification provided below:

$$P^1_t = \alpha + \beta_o T + \Sigma^J_{j-1} \beta_j P^1_{t-j} + \Sigma^K_{k-1} h_k P^2_{t-k} + \varepsilon_t$$

where T is the time trend, εt is the error term.

Lags for the ADL model were selected to minimize the Akaike s Information Criterion. Granger causality tests were specified as:

$$\boldsymbol{P^1_t = \alpha + \beta_o T + \sum^J_{j-1} \beta_j P^1_{t-j} + \sum^K_{k-1} h_k P^2_{t-k} + \varepsilon_t}$$

$$\boldsymbol{H_o: h_1 = h_2 = \ldots\ldots\ldots = h_t = 0}$$

$$\boldsymbol{P^2_t = \delta + \phi_o T + \sum^J_{j-1} \Omega_j P^1_{t-j} + \sum^K_{k-1} \phi_k P^2_{t-k} + v_t}$$

$$\boldsymbol{H_o: \phi_1 = \phi_2 = \ldots\ldots\ldots\ldots = \phi_K = 0}$$

Co-integration

Co-integration means that despite being individually non-stationary, a linear combination of two or more time series can be stationary. The series that satisfy this requirement are said to be co-integrated. Following Granger (1981), a time series x_t which has a stationary, invertible, non-deterministic ARMA representation after differencing *d* times is integrated of order *d* and is denoted by $x_t <\sim I(d)$. The components of the vector x_t are said to be co integrated of order *d, b*, denoted CI (d,b), if all the components of *xt* are I(d); there exists a vector "x_t is 1(d-b), b>0. The vector is then called a co integrating vector. A necessary condition for co integration is that the data series for each variable involved exhibit similar statistical properties, that is, to be integrated to the same order with evidence of some linear combination of the integrated series.

Error correction model

Although price transmission analysis is a useful tool for understanding and predicting price trends, it only tells us about the relationship between two prices over time. It does not tell us why the price transmission is strong or weak, fast or slow (Engle and Granger, 1987). This interpretation can only be done with local knowledge of transportation routes, seasonal flows in staple foods, trade and agricultural marketing policies, the availability of foreign exchange and credit, the ease of obtaining permits, and the competition for overland freight, among other factors.

Results and discussion

Market integration

To verify level and first differenced price series were indeed stationary, Augmented Dickey-Fuller (ADF) unit root test was used. The ADF test results are presented for the period Jan 2005 to December 2020 (Table 1). The equations were estimated with an intercept and time trend. The results are presented in Table 1 for Augmented Dickey-Fuller (ADF) unit root tests for each series. The null hypothesis of non-stationarity was tested based on the critical values reported by MacKinnon. All the price series appeared non stationary in the levels, but all the series were stationary after taking first differences. After

Table 1. ADF Unit root test for soybean in selected markets of India

Variable	Level	P-value	First difference	P-value
Bidar	-2.0360	0.2713	-12.2399**	0.0000
Dharwad	-2.9306	0.0439	-10.6947**	0.0000
Latur	-1.8967	0.3333	-10.1346**	0.0000
Amravati	-1.8982	0.3326	-10.5565**	0.0000
Dewas	-2.5769	0.0997	-15.8037**	0.0000
Ujjain	-2.0948	0.2471	-19.0356**	0.0000

Note: ** Significant at 1 per cent level

confirming the currency exchange rates were stationary in their first differences, co integration between the commodity futures was tested using Johansen s maximum likelihood procedure. The bivariate co-integration technique of Engle and Granger was also tested for the presence of long run relationship existing between soybean price in different states.

Granger casualty test

The causal relationship among the markets price of major soybean markets in India were approached through Granger s Causality technique and presented in Table 2. It could be seen that existence of mostly unidirectional causality as well a bidirectional causality among soybean selected markets. The unidirectional relationship was found for the pair of Madhya Pradesh market, indicates that price of Dewas market influence the price of Karnataka and Maharashtra market. Similarly, bidirectional causality was exerted on Bidar and Amaravati

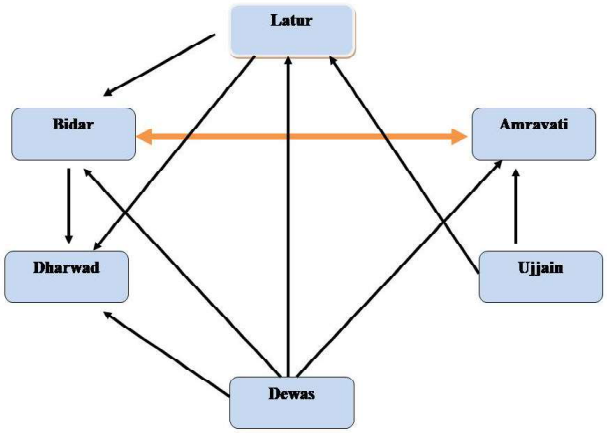

Fig. 1: Pairwise granger causality of soybean markets

Comments: The paper lacks discussion of the results. The results are not presented clearly, theoretical explanation is more.
Concise Methodology.
Include few realted and recent references and delete all old references.
Conclude the outcome of the study precisely in last para.
Revise the MS thoroughly as suggested and resubmit immediately.

markets of Karnataka and Maharashtra evidencing the proximity of interstate price transmission (Fig. 1).These results are in accordance with study reported by Murulidhar (2018) in Karnataka for Maize crop in Davangere, Hasan and Haveri

Table 2. Pairwise granger causality test for soybean markets in India

Null hypothesis	F – statistic	P – value
BIDAR does not Granger Cause AMARAVTI	3.7484 *	0.0255
AMARAVTI does not Granger Cause BIDAR	7.4796**	0.0008
DEWAS does not Granger Cause AMARAVTI	28.6219**	0.0000
AMARAVTI does not Granger Cause DEWAS	1.1892	0.3069
DHARWAD does not Granger Cause AMARAVTI	0.8659	0.4225
AMARAVTI does not Granger Cause DHARWAD	20.4238**	0.0000
LATUR does not Granger Cause AMARAVTI	1.4153	0.2456
AMARAVTI does not Granger Cause LATUR	4.3869	0.0139
UJJAINI does not Granger Cause AMARAVTI	9.1906**	0.0002
AMARAVTI does not Granger Cause UJJAINI	2.7949	0.0639
DEWAS does not Granger Cause BIDAR	11.8482**	0.000
BIDAR does not Granger Cause DEWAS	2.6318	0.0748
DHARWAD does not Granger Cause BIDAR	0.6190	0.5397
BIDAR does not Granger Cause DHARWAD	19.2344**	0.0000
LATUR does not Granger Cause BIDAR	5.0759*	0.0072
BIDAR does not Granger Cause LATUR	2.4159	0.0923
UJJAINI does not Granger Cause BIDAR	3.6795	0.0272
BIDAR does not Granger Cause UJJAINI	2.1353	0.1213
DHARWAD does not Granger Cause DEWAS	2.0272	0.1348
DEWAS does not Granger Cause DHARWAD	16.8865**	0.0000
LATUR does not Granger Cause DEWAS	1.1252	0.3269
DEWAS does not Granger Cause LATUR	30.9791**	0.0000
UJJAINI does not Granger Cause DEWAS	1.6116	0.2025
DEWAS does not Granger Cause UJJAINI	4.1013	0.0182
LATUR does not Granger Cause DHARWAD	19.7307**	0.0000
DHARWAD does not Granger Cause LATUR	1.0708	0.3450
UJJAINI does not Granger Cause DHARWAD	6.850*	0.0014
DHARWAD does not Granger Cause UJJAINI	2.0096	0.1372
UJJAINI does not Granger Cause LATUR	5.1480 *	0.0067
LATUR does not Granger Cause UJJAINI	2.5708	0.0794

Note: **Significant at 1 per cent level; * Significant at 5 per cent level;

Table 3. Johansen's multiple co-integration analysis for soybean in selected markets unrestricted co integration rank test (Trace) Trace statistics of Series Amravati, Bidar, Dewas, Dharwad, Latur and Ujjain

No. of CE(s)	Eigen value	Statistic	Critical value	Probability
None	0.2050	113.03**	95.75	0.0019
At most 1	0.1437	72.88*	69.81	0.0279
At most 2	0.1105	45.72	47.85	0.0781
At most 3	0.0637	25.23	29.79	0.1532
At most 4	0.0586	13.70	15.49	0.0913
At most 5	0.0177	3.13	3.84	0.0765

Note: Critical values based on MacKinnon (1999); LR test indicated 2 co-integrating equation **Significant at 1 per cent level, *Significant at 5 per cent level.

markets. Thus a strong integration of major soybean markets in India is confirmed that the price of one market influence the price of other markets through the result of the study.

Results of Jahansen's multiple co-integration analysis

Since all the price series are non-stationary at level form and stationary at first difference level, Johansen co-integration test can be applied to analyze the long run equilibrium among the soybean markets. The results of the analysis shown that there was at least two co-integration equations, at 5 per cent level of significant (Table 3).,which indicated the long run equilibrium among the four major markets.

Vector error correction model

For the present study, the Vector Error Correction Mechanism (VECM) was adopted to analyze the long run association between the markets under co-integration framework. Accordingly, VECM were computed and the results are presented in Table 4. Two month lag prices of Amaravati market any variations in the prices will get it corrected by itself within 38.62 per cent of time. Two month lag prices of Bidar market any variations in the prices will get it corrected by itself within 28.61 per cent of time and will have an impact on the present prices in Latur market only to an extent of 16.59 per cent in opposite direction. One month previous prices in Dewas market will have an impact on the present prices in Amaravati market only to an extent of 18.84 per cent and 17.98 per cent on Latur market, in opposite direction. One month lag prices of Dharwad market any variations in the prices will get it corrected by itself within 15.61 per cent of time. Two month previous prices of Dharwad market any variations in the prices will get it corrected by itself within 38.78 per cent of time (within 11 days). Two month lagged prices of Latur market will have impact on present prices in Bidar market to an extent of 53.59 per cent in positive direction. Similar results were observed in the study of Akshatha *et al.* (2020) who reported price transmission of different groundnut oil markets in the country.

Table 4. Reduced form vector error correction estimates for soybean markets

Error Correction	D(Amravati)	D(Bidar)	D(Dewas)	D(Dharwad)	D(Latur)	D(Ujjain)
ECM	*0.2490*	*0.1268*	*-0.1657*	*0.3446*	*0.3169*	0.0604
	[5.7911]	[2.0979]	[-2.0136]	[2.4083]	[8.1814]	[0.4432]
D(AMARAVTI(-1))	-0.0016	0.2460	0.4834	0.0089	0.1504	0.2776
	[-0.0116]	[1.2116]	[1.7490]	[0.0186]	[1.1564]	[0.6062]
D(AMARAVTI(-2))	*-0.3862*	-0.3801	0.0682	-0.2866	-0.2432	-0.6968
	[-2.7499]	[-1.9248]	[0.2537]	[-0.6134]	[-1.9232]	[-1.5641]
D(BIDAR(-1))	-0.0181	-0.0093	0.1514	0.0089	-0.0396	-0.1383
	[-0.2935]	[-0.1070]	[1.2797]	[0.0435]	[-0.7122]	[-0.7057]
D(BIDAR(-2))	-0.1102	*-0.2861*	0.0974	-0.0021	*-0.1659*	-0.2170
	[-1.8139]	[-3.3488]	[0.8379]	[-0.0106]	[-3.0322]	[-1.1263]
D(DEWAS(-1))	*-0.1284*	-0.0638	-0.1182	-0.2209	*-0.1798*	0.0521
	[-2.6614]	[-0.9404]	[-1.2800]	[-1.3755]	[-4.1352]	[0.3403]
D(DEWAS(-2))	0.0124	0.0202	-0.0313	-0.0772	-0.0651	-0.0626
	[0.2704]	[0.3132]	[-0.3564]	[-0.5057]	[-1.5752]	[-0.4301]
D(DHARWAD(-1))	0.0205	0.0030	-0.0071	*-0.1561*	0.0223	-0.0252
	[0.9373]	[0.0975]	[-0.1703]	[-2.1384]	[1.1324]	[-0.3631]
D(DHARWAD(-2))	0.0192	-0.0581	-0.0620	*-0.3878*	0.0297	-0.0604
	[0.8933]	[-1.9196]	[-1.5035]	[-5.4067]	[1.5332]	[-0.8835]
D(LATUR(-1))	0.2519	0.0118	-0.5048	0.3321	0.1287	-0.0431
	[1.5803]	[0.0529]	[-1.6543]	[0.6262]	[0.8965]	[-0.0854]
D(LATUR(-2))	0.2644	*0.5359*	-0.2650	0.7434	0.2407	0.6625
	[1.7356]	[2.5014]	[-0.9088]	[1.4666]	[1.7540]	[1.3710]
D(UJJAINI(-1))	*0.0576*	0.0244	0.0827	0.0070	0.0186	*-0.3989*
	[2.3298]	[0.7037]	[1.7487]	[0.0857]	[0.8364]	[-5.0850]
D(UJJAINI(-2))	-0.0288	-0.0419	0.0308	-0.0648	-0.0246	-0.1588
	[-1.1181]	[-1.1582]	[0.6255]	[-0.7566]	[-1.0626]	[-1.9436]
C	15.88	15.21	14.65	17.01	17.14	23.96
R-squared	0.32	0.17	0.11	0.24	0.413	0.17
AIC	13.3442	14.0261	14.6427	15.7485	13.1351	15.6530

Note: Bold and italics are the significant variable & t-statistics in [ ]

The analysis of one month lagged prices in Ujjain market indicated that any variations in the prices will get it corrected by itself within 39.89 per cent of time and will also have impact on present prices in Amravati market to an extent of 5.76 per cent in positive direction. In all other markets though there exists Co-integration between the prices but they were insignificant

Conclusion

The domestic soybean markets are highly integrated. Price transmission among domestic soybean market is proved since it had long run association with the domestic markets. Results of the time series econometric analyses confirmed that domestic soybean markets were integrated with international soybean market and the world prices are transmitted to the domestic markets. Results of Johansen s multiple co- integration tests revealed that the domestic soybean markets of Dewas, Ujjain, Amaravati, Latur, Bidar and Dharwad, are integrated with at least two co-integration vectors. Dewas market of Maharashtra seems to be a independent markets for deciding the price of soybean crop in the in the present study by confirming unidirectional price influence on all other markets except Ujjain market, As price transmission occurs across the different States Bidar market of Karnataka and Amaravati market of Maharashtra exhibits bidirectional price transmission among them with respect to soybean.

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