



## Research Article

# CO-INTEGRATION AND CAUSALITY: AN APPLICATION TO GARLIC MARKETS IN CENTRAL INDIA

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**Abstract-** Madhya Pradesh being the leading garlic producing state of India contributes about one-fourth of the total Indian production. The aim of this paper is to assess the extent and integration among garlic markets and to study price movement of garlic in Madhya Pradesh. For study purpose time series secondary data related to monthly average wholesale prices and arrivals of garlic were collected from major markets in Madhya for the period 2001-02 to 2013-14. The econometrics tools viz. Moving average, ADF based unit root test, Johansen's co-integration test, Granger causality test etc. were used to analyse the collected data. Negative relationship was observed between price and arrival for garlic in the markets of central India. The prices of garlic were non-stationary and observed higher in the months from November to January across the selected markets. The price series showed the consequences of unit root and were stationary at first difference. Long run equilibrium relationship and co-integration between selected markets were observed. Most of the selected markets showed unidirectional influence on garlic prices of each other and function as a satellite market and assimilate information.

**Keywords-** ADF based unit root test, Johansen's co-integration test, Granger causality test

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## Introduction

Madhya Pradesh is the largest producer of garlic and has a largish share of the national produce. About 30 percent area of garlic production of India is under M.P. Madhya Pradesh has more than 60 thousand hectare under garlic cultivation with a total production of 270 thousand MT and productivity level of 4.50 tonnes per hectare during the year 2013-14. The variation in the output of garlic lead to wide fluctuations in their prices exposing the growers to more risk. Moreover due to their perishable nature garlic crop require immediate marketing to ensure quality produce to the consumer and remunerative prices to the growers.<sup>[1]</sup> The lack of market intelligence about the potential markets and the pattern of arrivals and prices further add to the woes of the garlic growers. Therefore, the need for proper marketing intelligence system has been felt and raised from time to time by many scholars. The ongoing process of privatization and globalization has further compounded the difficulties of marketing high value crops of reasonable prices. The availability of market intelligence on aspects like the potential markets, the quantum of market arrivals and prevailing prices in different regional and national markets during different months of a year shall go a long way in mitigating many of these problems and help the farmers to decide on future production plan on their farms and its marketing schedule. Against this backdrop the present study was undertaken to gain insights into the behaviour of garlic of the prices of garlic and the extent of spatial price integration between the garlic markets in Madhya Pradesh.

## Materials and Methods

### Research Design

- The study area:** The study is confined to Madhya Pradesh. The weekly time series data on arrivals and prices of garlic were collected from five major garlic markets of Madhya Pradesh based on highest arrivals.
- Selected markets:** Indore, Mandsaur, Neemuch, Ratlam and Ujjain.

iii) **Period of Study:** Year 2001-02 to 2013-14

iv) **Analysis of Data:**

Following econometric techniques were used to analyse the collected data.

- For behavior of arrivals and prices: Seasonality analysis
- For stationarity: ADF unit root test
- For Integration: Johansen's multiple co-integration test<sup>[2]</sup>
- For direction of causation: Granger causality test between selected markets.

## Results and Discussions

### Seasonal Indices of garlic arrivals and Prices

Garlic is seasonal spice crop and their production and consequently their supply in the market is subject to natural vagaries. The supply of such commodity on one hand and the demand for them on the other, at a particular time and market will determine the wholesale price. The change in determinates of supply and demand over a period of time will affect the price which will lead to seasonality effect in price series that is generally more during off-seasons. The analysis of such seasonal and other components of time series on wholesale prices and arrivals of garlic is very important from producer's consumers and policy makers stand point. There are four components of price fluctuation viz., seasonal secular trend, cyclical and irregular variations. The irregular variations have no defined pattern, hence is of no policy importance.

The seasonal indices computed for garlic arrivals in different markets of Madhya Pradesh inferred that higher indices of markets arrivals were noticed immediately after harvest in different months i.e. February to May. The lower value of indices of arrivals during the period of October to January indicated lean period in garlic for different markets of Madhya Pradesh as shown in [Table-1]

In respect of price indices of garlic shown in [Table-1] lower price values were observed during the months of February to May in different markets of the state. These months are the post-harvest months of garlic crop, where the crop comes in the markets in large quantity. The highest value of price indices were observed during lean period and lowest arrivals months from October to January in different markets.

To sum up, seasonal fluctuations were observed both in markets arrivals as well as prices of garlic across the selected markets. It can further be observed that seasonality in price was higher as compared to market arrivals in all the selected markets. Low seasonality in markets arrivals in all the selected markets in because of the standardization of production and protection technologies of garlic

crop. However, higher price variability is because of the imperfection in the markets and marketing systems of garlic.

### Validity test

#### ADF Test:

Co-integration is a statistical property of time series variables or when the error term in the regression modeling is stationary. If there exists a stationary linear combination of non-stationary random variables, the variables combined are said to be co-integrated. So co-integration means there is some linear combination of the set of variables that is stationary [3].

**Table-1** Seasonal indices of monthly arrival and prices of garlic in different markets of Madhya Pradesh (In percent)

Month/ markets	Indore		Mandsaur		Neemuch		Ratlam		Ujjain		M.P.	
	AR	PR	AR	PR	AR	PR	AR	PR	AR	PR	AR	PR
January	71	122	54	118	62	107	56	126	37	111	56	125
February	180	87	188	77	96	79	153	86	68	81	153	82
March	255	72	192	69	125	69	182	68	192	70	182	66
April	113	71	117	73	185	65	143	72	194	68	143	68
May	74	78	64	81	102	73	81	76	113	83	81	74
June	68	84	59	79	96	82	72	74	91	85	72	86
July	61	89	80	99	68	100	72	95	60	95	72	101
August	47	95	83	105	77	112	50	104	65	107	50	106
September	81	113	125	116	108	119	120	115	134	107	120	114
October	81	118	62	117	93	123	75	117	75	114	75	120
November	85	132	111	133	108	131	107	12	99	122	107	120
December	83	140	67	133	81	140	88	144	70	157	88	138

AR= Arrivals

PR= Prices

Augmented Dickey fuller test procedure was done to check whether the price series of garlic were stationary or not. From [Table-2] it could be inferred that Augmented Dickey Fuller test value are above the critical 1 percent level given by Mackinnon statistical table at levels implying that the series are non-stationary indicating the existing of unit root. After taking the first difference, all the series become stationary which means that the calculated values for all the markets are less than the critical value (1%) and free from the consequence of unit root. The result of Augmented Dickey Fuller (ADF) unit root test for garlic showed that the level data were non-stationary but their first differences were stationary. Hence, all markets price series were integrated of the order 1 i.e. I(1).

was a bidirectional influence on prices of Mandsaur and Indore markets.

**Table-3** Johansen's co-integration test results for Garlic market of Madhya Pradesh

Unrestricted Co integration Rank Test (Trace)				
Hypothesized No. of CE(s)	Eigen Value	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.261159	98.36422	69.81889	0.0001
At most 1 *	0.143442	52.66067	47.85613	0.0165
At most 2	0.079579	29.28091	29.79707	0.0572
At most 3 *	0.066376	16.75938	15.49471	0.0321
At most 4 *	0.041425	6.388429	3.841466	0.0115

Trace test indicates 2 cointegration(s) at the 0.05% level

\* denotes rejection of the hypothesis at the 0.05% level

\*\*MacKinnon-Haug-Michelis(1999) p-value

### Johansen's co-integration

Based on the Johansen's co-integration procedure the integration between the markets was analyzed using E-views Software. The trace test results presented in [Table-3] for garlic price showed that trace statistics value was greater than the critical value at 5 percent level. Hence, we obtained at least four co-integrating equations at 5 percent level of significance. This indicated that the model variables had a long run equilibrium /co movement among the Indore, Mandsaur, Neemuch, Ratlam and Ujjain markets price series during the periods under study. The existence of co-integration is necessary for long-term market efficiency [4].

**Table-2** The Augmented Dickey Fuller based unit root test

Market	Augmented Dickey-Fuller (ADF)		Critical value (1%)
	Level	1 <sup>st</sup> difference	
Indore	-0.093910(0.0046)	-0.906324(0.0000)	-3.473672
Mandsaur	-0.149297(0.0035)	-1.408047(0.0000)	-3.473672
Neemuch	-0.125998(0.0013)	-0.971564(0.0000)	-3.473672
Ratlam	-0.126392(0.0013)	-1.052391(0.0000)	-3.473672
Ujjain	-0.147910(0.0031)	-1.238776(0.0000)	-3.473672

\*\*Significant at 1% level

### Pairwise Granger Causality Tests for prices of Garlic markets of MP

Granger Causality test was employed to know the direction between the markets. Theoretically a variable if the current value is conditional on the past data. The results of pairwise Granger Causality test as shown in [Table-4]. Inferred that there

It means the prices of Mandsaur market also influenced Indore market and prices of Indore market also influenced Mandsaur market. There was a unidirectional influenced on prices of Neemuch and Indore, Indore and Ratlam, Ratlam and Ujjain, Mandsaur and Neemuch, Ujjain and Mandsaur, Indore and Ujjain, Neemuch and Ratlam, Ratlam and Ujjain Markets.

### Relationship between markets Arrivals and Prices

The phenomenon of inverse relationship between market arrivals and prices is well known, nevertheless, factors such as the availability of cold storages facilities, enhanced opportunities for export value addition through agro-processing, availability of new poly-house technologies etc. not only weaken this inverse relationship but may even turn it positive. The degree of relationship between market arrivals and prices of garlic crop was studied for different years from 2002 to 2014 by computing correlation coefficient. The relationship was also studied for different months over different years. This was necessitated due to the seasonality in garlic production. The negative relationship may be more pronounced during the peak season and it may be positive for other months moreover, given the scope for varying the cropping pattern, the relationship between markets arrivals and prices in different months may be more fruitful in that it encourage farmers to

adjust their cropping pattern and sell at a time when prices were reasonably high. The results of correlation analysis, given in [Table-5] reveal that the negative relationship between market arrivals and prices was not universally true for all years. For example in Indore market, a statistically negative relationship was noticed for more of the years while positive statistical significance was evidenced only for four years and correlation coefficient were positive though statistically

non-significant for two years. The month wise correlation coefficient between arrivals and prices for garlic crop were positive in a few cases albeit non-significant in most of the cases. A positive and significant correlation coefficient in (January, February, March, April, June) may be attributed to the fact that the Indore market receives off-season supplies of garlic from surrounding districts and states.

**Table-4** Pair wise Granger Causality tests for price of Garlic Markets

Null Hypothesis	F- statistic	Prob.	Direction	Relationship
MANDSAUR does not Granger Cause INDORE	3.10118*	0.0479	Bidirectional	Man ↔ Ind
INDORE does not Granger Cause MANDSAUR	16.106**	5.E-07		
NEEMUCH does not Granger Cause INDORE	0.49754	0.6090	Unidirectional	Ind → Nee
INDORE does not Granger Cause NEEMUCH	5.62574**	0.0044		
RATLAM does not Granger Cause INDORE	0.80317	0.4498	Unidirectional	Ind → Rat
INDORE does not Granger Cause RATLAM	19.1666**	4.E-08		
UJJAIN does not Granger Cause INDORE	2.27878	0.1060	Unidirectional	Ind → Ujj
INDORE does not Granger Cause UJJAIN	6.77892**	0.0015		
NEEMUCH does not Granger Cause MANDSAUR	17.3258**	2.E-07	Unidirectional	Nee → Man
MANDSAUR does not Granger Cause NEEMUCH	0.83613	0.4354		
RATLAM does not Granger Cause MANDSAUR	9.30353**	0.0002	Unidirectional	Rat → Man
MANDSAUR does not Granger Cause RATLAM	1.89397	0.1541		
UJJAIN does not Granger Cause MANDSAUR	13.2992**	5.E-06	Unidirectional	Ujj → Man
MANDSAUR does not Granger Cause UJJAIN	1.52403	0.2212		
RATLAM does not Granger Cause NEEMUCH	1.52993	0.2199	Unidirectional	Nee → Rat
NEEMUCH does not Granger Cause RATLAM	9.09159**	0.0002		
UJJAIN does not Granger Cause NEEMUCH	2.08989	0.1273	Unidirectional	Nee → ujj
NEEMUCH does not Granger Cause UJJAIN	2.90682*	0.0578		
UJJAIN does not Granger Cause RATLAM	10.2327**	7.E-05	Unidirectional	Ujj → Rat
RATLAM does not Granger Cause UJJAIN	0.533198	0.5889		

**Table-5** Relationship between arrivals and wholesale prices in selected markets of Madhya Pradesh (2002-14)

Year	Indore	Mandsaur	Neemuch	Ratlam	Ujjain	MP
2002	-0.235	0.743***	0.643**	-0.297	-0.149	0.864***
2003	-0.008	0.02	-0.28	0.102	-0.044	0.048
2004	-0.271	0.247	0.53*	0.214	0.001	0.158
2005	-0.431	-0.616**	-0.516*	-0.658**	-0.654**	-0.619**
2006	-0.55	-0.674**	0.367	-0.687**	-0.563*	-0.709***
2007	-0.302	-0.287	0.048	-0.622**	-0.594**	-0.39
2008	0.824**	0.657**	-0.237	0.115	0.3	-0.454
2009	-0.503*	0.575*	-0.013	-0.137	0.454	0.12
2010	-0.601**	0.612**	-0.431	-0.741***	-0.654**	0.253
2011	-0.229	-0.324	-0.472	0.143	-0.321	-0.102
2012	0.041	-0.187	-0.342	-0.21	-0.325	-0.198
2013	-0.008	-0.39	-0.653**	-0.438	-0.348	-0.647**
2014	0.124	-0.513*	-0.118	-0.096	0.086	-0.557*

**Table-6** Relationship between monthly arrivals and wholesale prices in selected markets of Madhya Pradesh (2002-14)

Months	Indore	Mandsaur	Neemuch	Ratlam	Ujjain	MP
January	0.427*	0.119	-0.137	-0.095	-0.325*	-0.005
February	0.643*	0.400*	0.255	-0.064	-0.038	0.496*
March	3.106*	0.074	0.198	-0.116	-0.001	0.301*
April	0.291*	-0.224	0.431*	-0.017	-0.004	-0.017
May	-0.067	-0.229	0.132	-0.217	-0.259	-0.025
June	0.006	0.235	0.018	-0.105	-0.372*	0.030
July	0.234	0.087	0.163	-0.051	-0.142	0.031
August	-0.169	0.042	0.012	-0.281	-0.015	-0.065
September	-0.128	0.105	-0.029	-0.102	-0.093	0.195
October	-0.084	0.318*	-0.049	-0.201	-0.055	0.221
November	-0.069	0.829***	0.021	-0.148	-0.054	0.284
December	-0.211	0.292*	-0.200	-0.268	-0.140	-0.039

\*\*\*Significant at 1% level, \*\*Significant at 5% level, \*Significant at 10% level.

## Policy Implications

The policy implications based on the findings of the present study are as follows-

- 1) Seasonal indices of arrivals and prices indicated that the prices were low during high arrivals and vice versa. Hence, the producers may be advised to plan their production as well as sale of the crop output. Further the inadequacy of storage facilities is another serious bottleneck. Hence, there is urgent need to popularize 'Grameen Bhandar Yojna' to bring stabilization in the prices of agricultural commodities. Fluctuations in market arrivals and prices were found to be uneven

across the markets. Hence, there is a need to have a constant watch on prices and arrivals of the crop so that the farmers can know the variations occurring in the arrivals and prices during certain period in the market and bring the produce at the right time to avoid the price crash in garlic. The regulated market should take necessary steps to see that the dissemination of market information regarding the arrivals and prices reaches the farmers of the remotest places.

- 2) It has observed from the study that there is strong association among

the markets, thereby influencing the prices from one market to another market. This help to transfer the price signals from one market to another and thereby help in stabilization of prices and create a healthy competitive environment. This would also a long way help to protect the interest of producer-sellers.

- 3) With the help of regression, wholesale prices were forecasted which showed an increasing trend, with due consideration to seasonality in this regard farmers may be advised to plan the production process and decide when to sell the produce so that they would get a higher price for their produce. In this regard, APMCs should provide the basic infrastructural facilities to the farmers.
- 4) Market infrastructural facilities like warehousing transportation, processing etc. should be established to help the growers in storage of their produce in the glut season and then take advantages of off-seasons prices in order to eliminate the seasonality in market arrivals of garlic and this also minimize the price volatility.

### Conclusion

The study leads to concludes that garlic is a good foreign earner crops as large quantities of garlic are exported every year from the state of Madhya Pradesh. The state is leader in the production of garlic in the country. The variability in the market arrivals was more pronounced in the Indore than the remaining four markets. The price variability was however, more marketed in the Neemuch market with value of coefficient of variation in most of the months staying above 50 percent, the study has confirmed the negative relationship between market arrivals and prices over the years in all the selected markets. However, across different months, there have been several instances of positive relationship between arrivals and prices which could be attributed to the off-season supplies of garlic which fetch higher prices. In Indore market, statistically significant negative relationship is evidence for most of the years, but positive and non-significant relation were also observed in few years. A similar pattern has been observed in other selected markets, with a fewer cases of statistical significance. The prices more contrary to arrivals and seasonal nature of garlic creates glut in the market which leads to sharp fall in prices during the post harvest season and lowering farmers income.

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### Author's Contribution

All authors contributed equally to the preparation of manuscript. Namita Nagre collected the required data while Apoorwa Tomar analyzed the data using suitable econometrics tools and techniques. Dr. P.K. Awasthi interpreted the results and wrote the manuscript and Dr. N.K. Raghuwanshi gave intellectual insight and technical advice. All authors discussed the results and findings of the manuscript at all stages.

### Abbreviations

M.P.- Madhya Pradesh, AR- Arrivals, PR- Prices, ADF- Augmented Dickey Fuller, p-value- probability-value, APMC- Agricultural Produce Market Committee

### Conflict of Interest: None declared

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