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Market Integration and Price Transmission Analysis of Onion in Regional Markets of Karnataka

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ABSTRACT

Background: Onion markets in Karnataka have experienced significant price volatility in recent years, necessitating an examination of market integration across regional markets to understand price transmission mechanisms and validate the law of one price across different trading centers.

Aims: This study aimed to examine the market integration of onion wholesale prices across six regional markets in Karnataka during 2004-2023 and assess whether these markets shared a common linear deterministic trend and long-run equilibrium relationships.

Materials and Methods: Monthly wholesale price data from six Karnataka markets were analyzed using Augmented Dickey-Fuller test for stationarity, Johansen co-integration test for long-run relationships, and Granger causality test for price transmission dynamics. The analysis employed both Trace and Maximum Eigen-value statistics to confirm co-integration relationships.

Results: The Trace and Maximum Eigen-value statistics confirmed long-run equilibrium relationships among onion prices across all Karnataka markets studied. Granger causality analysis revealed bi-directional causality between multiple market pairs: Hubballi-Belagavi, Hubballi-Vijayapur, Hubballi-Kolar, Hubballi-Tumakuru, Belagavi-Vijayapur, Belagavi-Kolar, Belagavi-Tumakuru, and Mysore-Tumakuru. Hubballi emerged as the dominant price-determining market, followed by Belagavi.

Conclusion: The onion markets in Karnataka demonstrate significant market integration with established long-run equilibrium relationships, validating the law of one price across the regional markets studied during the 2004-2023 period.

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Key Message: Strengthening market integration through improved infrastructure development and enhanced market information systems is essential to ensure price stability and support sustainable agricultural development in Karnataka's onion marketing sector.

KEYWORDS

• Onion Markets • Market Integration • Co-Integration • Granger Causality • Price Transmission • Karnataka

INTRODUCTION

Onion is an important vegetable traditionally used as a food ingredient in the Mediterranean diet that has a high production, domestic, and foreign trade worldwide. India's total horticulture area was 28.12 million hectares, with a total production of 351.92 million tonnes (Anonymous, 2023). Onion being a household vegetable for daily consumption, its price rise has significant impact on trade, exports and household budget allocation (Sohan, Premi and Premi B R, 2017). Unanticipated and substantial price fluctuations can lead to low production and instability in farm income as they discourage farmers from adopting improved production methods (Anuja *et al.* 2013). Onion is considered as the most highly volatile crop among the vegetables, showing increasing fluctuation of unexpected price spikes & falls. In the last two decades, among the food commodities, onion is one of the commodities which experienced high volatility in price movement. In general, this commodity is less elastic to price and income and inherently unstable due to weather and institutional risks (Chengappa *et al.,* 2012). Market integration also plays a vital role in determining pattern and pace of diversification towards the high value crops (Sidhu *et al.,* 2010). Market integration as a measure of the extent to which demand and supply in one location are transmitted to another (Wani *et al.* 2015). Market integration is not merely a matter of economic significance but holds broader implications for transparency, stability, and fairness within the agri-food system. Karnataka is the third largest producer of onion in India with production 16.38 Metric Tonnes in 2023-24. The objective of the present study to identify the spatial linkages among the regional onion markets in Karnataka, recognizing that their interconnectedness provides essential market signals.

The present study uses Augumented Dicky fuller test, Johnasen co-integration and Granger causality test for estimating the market integration and studying the direction of causality in the long run in the selected regional markets of Karnataka.

METHODOLOGY

Time series data of monthly duration for the prices of onion were collected from the portal of AGMARKENT from the year January 2004 to December 2023 for the study under consideration. Except Bengalore onion market Belagavi, Hubballi, Vijayapur, from Northern Karnataka and Kolar, Mysore, Tumakur from Southern Karnataka were selected as regional market respectively for the study. Because Bengalore market operates under different dynamics than other regional markets, due its unique characters like large population, urbanization and Migration pattern influence onion demand and prices. The data collected for the study was analysed using the E-views 12 Student Version.

Techniques and Tools Use

1. Unit root test

Stationarity in the data series explains the order of differences & it is utmost important for the markets to be in the same order in order to perform co-integration between market pairs. It is very important to test whether or not the time series is stationary because if a time series is not stationary, its behaviour can only be studied for the time period under consideration, it cannot be generalized to other periods & thus one cannot predict such a time series data. So in order to test the data is stationary or having unit root, the famous test known as Augmented Dickey-Fuller (ADF) test is used. The presence of unit root (non-stationary) in the underlying series is tested

by performing Augmented Dickey-Fuller test using the following regression:

$$\Delta Yt = a + \beta iT + \delta i Y_{it-1} + bi \sum_{i-1}^{p} \Delta Y_{it-1} + e_t \quad (1)$$

Where, Y_{it} = Price of a commodity in a given market 'i' at a time 't'; $\Delta Y_{t-i} = (Y_{t-i} - Y_{t-2})$ (t-i lagged prices & Δ is Differenced series); *et* is pure white noise error-term, α is the drift parameter, T is the time trend effect, βi, δi & *bi* is coefficients. The null hypothesis that ρ = 0; signifying presence of unit root, i.e., the time series is non-stationary and the alternative hypothesis is ρ < 0 signifying the time series is stationary, therefore, rejecting the null hypothesis.

2. Johansen co-integration test

The ADF test was supplemented by Johansen-Juselius Maximum Likelihood Method. The maximum likelihood (ML) approach of cointegration is used to examine the long-run relationship between wholesale prices of onion in selected markets of karnataka.

The Johansen technique examines a Vector Auto Regression (VAR) model of Yt, an (n x l) vector of variables that are integrated of the order one - I time series. This VAR can be expressed as equation:

$$Y_t = \mu + \sum_{i=1}^{p-1} \Gamma_i Y_{t-1} + \Pi Y_{t-1} + \varepsilon t \quad (2)$$

Where, *Γ* & Π are matrices of parameters, p is the number of lags (selected on the basis of Akaike information criterion), εt is an (n x l) vector of innovations. Both Γ and Π are the n*n matrixes of the coefficient conveying the short and long run information respectively and εt is the n-dimensional vector of the residuals that is identical and independent distributed. To measure the number of cointegrating vectors, Johansen and Juselius developed two likelihood ratio test statistics (Trace and Max Eigen test statistics) represented as equations:

$$J_{trace} = -T \sum_{i}^{n} \ln (1 - \hat{\lambda_i}) \quad (3)$$

$$J_{max} = -T \ln(1 - \hat{\lambda_i} + 1) \quad (4)$$

Where, T is the sample size & $\hat{\lambda}$ is the i largest canonical correlation, r is the number cointegrated vector.r cointegrating vector(s) against the alternative hypothesis of n cointegrating relations. The Max Eigen statistic tested the null hypothesis (r =0) against the alternative (r + 1)

3. Granger causality test

Granger causality is a statistical concept of causality that is based on prediction. According to Granger causality, if a signal X "Granger causes" (or "G-causes") a signal Y, then present & past values of X may contain information that helps predict future Y. At the same time, it is important to note that Granger causality measures precedence & information content but does not by itself indicate causality. The causality test was attempted by the equation given below:

$$\Delta Y_{it} = \beta_0 + \beta_{1(t-1)} + \sum_{k=1}^{m} \delta_k \Delta y_{i(t-1)} \sum_{h-1}^{n} \alpha_h \Delta y_{j(t-h)} + \varepsilon_{it} \quad (5)$$

Where, Yit = market 'i' at time 't', Yjt = market 'J' at time 't' and m & n = number of lags determined by AIC. The null hypothesis is that X does not Granger cause Y. Rejection of the null hypothesis that $\alpha_h = 0$ where h =1, 2, 3,…, n indicates that prices in market "j" Granger-cause prices in market 'I'. If prices in market 'I' also Granger-cause prices in market 'j', then prices are determined by a simultaneous feed-back (SFM). This is the phenomenon of bi-directional causality. If the Granger causality runs one way, it is called unidirectional Granger-causality & the market which Granger causes the other is tagged the exogenous market.

RESULTS AND DISCUSSION

In the Table 1 shows that descriptive statistics of the selected markets prices. High instability/ volatility of prices has been remained in South Karnataka in case of Kolar market (145.62%) followed by Tumakur (142.58%) and Mysore (139.14%) market while comparatively less instability/ volatility in North Karnataka's markets. The probable reason for such instability is the impact of seasonal changes or crop losses, which can lead to significant market volatility. These factors interrupt the supply chain, affecting onion availability and pricing. As a result, instabilities in one market often ripple across other wholesale onion markets. This interconnectedness intensifies the instability, making it harder to maintain steady prices. Effective measures are needed to mitigate these distractions and stabilize the market. The skewness value for all the markets

show presence of asymmetric behaviour in them and also the coefficient of kurtosis is very high in Vijayapur market followed by Kolar, Belagavi and Mysore market which reflect the leptokurtic distribution and high degree of extreme values. Change in the pattern of arrivals in the market affects the price behavioural pattern as well as lack of proper supply of information to other wholesale markets may result in such changes.

Table 1: Descriptive Statistics of Onion Prices in selected Regional Markets in Karnataka

	North Karnataka			South Karnataka		
	Belagavi	**Hubballi**	**Vijayapur**	**Kolar**	**Mysore**	**Tumakur**
Mean	1648.056	1498.798	1548.941	1846.681	1550.875	1870.297
Median	1276.354	1163.311	1200.000	1500.000	1200.000	1400.000
Maximum	10472.41	8771.429	11555.56	11971.43	8891.304	8500.000
Minimum	376.4706	341.1765	314.0000	480.4348	387.1053	400.0000
Std. Dev.	1244.633	1117.388	1208.446	1268.139	1114.626	1311.767
CV%	132.41	134.13	128.18	145.62	139.14	142.58
Skewness	2.562468	2.242552	3.414233	3.308927	2.420382	1.857028
Kurtosis	14.09591	10.99027	24.63794	22.50162	12.44882	7.727367

1. Unit Root Test

Typically, the Johansen's procedure required that the time series should be integrated at order one, i.e., I (1). The time series data of onion prices in the selected markets were tested using the Augmented Dickey-Fuller (ADF) test to see whether they are stationary at their current levels, followed by their differences. The null hypothesis of both the tests is accepted or rejected based on the critical value and corresponding probability value. The lag length was selected using the Akaike Information Criterion (AIC). Results from the analysis mentioned in Table 2 revealed that prices were found to be non-stationary at their level in the Belagavi, Hubballi and Tumakur markets and stationary at their level in Kolar, Mysore an Vijayapur, but all selected markets become stationary after first differencing. Hence, the value of d was taken as 1 i.e., I(1) for all the markets.

Table 2: ADF test results of onion prices for selected Regional Markets of Karnataka

Region	Market	Level	First
North Karnataka	Belagavi	-2.324341 (0.1654)	-9.055940 (0.0000)
	Hubballi	-2.296287 (0.1743)	-8.678840 (0.0000)
	Vijayapur	-5.777205 (0.0000)	-6.944131 (0.0000)
South Karnataka	Kolar	-5.004271 (0.0000)	-4.967699 (0.0001)
	Mysore	-4.454843 (0.0003)	-8.565954 (0.0000)
	Tumakur	-3.203878 (0.0211)	-20.439320 (0.0000)

2. Johansen's Co-integration Analysis

Co-integration between the stationary price series was then evaluated using Johansen's Trace and Maximum Eigen-value tests as the following step. The Johansen procedure for the regional onion markets of Karnataka was applied by following the three steps, firstly appropriate lag length was chosen as suggested by the various lag length criterion. Secondly, the order of integration was confirmed by using the ADF and in the third step, two tests, i.e., trace and max Eigen statistics of Johansen's approach based on the vector autoregressive model (VAR) were put into the application to analyze the co-integrating vectors between the selected onion markets. Table 3 and Table 4 shows the results of Johansen's maximum likelihood tests (trace test and maximum eigen-value). The trace test and maximum eigen-value pits no cointegration (r = 0) against the alternative hypothesis (r ≥1) that at least one co-integrated equation predominated in the VAR system.

The result clearly indicates the existence of at least four co-integration equation. "The Trace and Maximum Eigen-value tests results showed that the onion prices in Karnataka moves together in the long run equilibrium. As a result, it may be stated that Karnataka's onion markets are well- functioning. Additionally, the Johansen's Trace and Maximum Eigen-value tests indicate that in these onion markets pairs, wholesale prices are competitive. The findings align with most regional studies, which suggest that domestic onion markets operate efficiently, with prices being effectively transmitted and co-integrated. Prices in onion

markets are not solely determined by market arrivals but are also influenced by factors such as variety, appearance, moisture content, colour, size, and shape. However, the efficient flow of market information across different markets can help to align prices and promote the realization of the law of one price.

Table 3: Unrestricted co-integration rank test (Trace) between onion markets

Hypothesized No. of CE(s)	Eigen value	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.798539	252.0265	95.75366	0.0000
At most 1 *	0.712993	159.1012	69.81889	0.0000
At most 2 *	0.597236	86.70277	47.85613	0.0000
At most 3 *	0.275567	33.95728	29.79707	0.0157
At most 4	0.231221	15.26005	15.49471	0.0542
At most 5	0.000153	0.008881	3.841465	0.9246

Trace test indicates 4 cointegrating eqn(s) at the 0.05 level.
*denotes rejection of the hypothesis at the 0.05 level.
**MacKinnon-Haug-Michelis (1999) p-values.

Table 4: Unrestricted co-integration rank test (Maximum-Eigen value) between onion markets

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.798539	92.92531	40.07757	0.0000
At most 1 *	0.712993	72.39839	33.87687	0.0000
At most 2 *	0.597236	52.74549	27.58434	0.0000
At most 3	0.275567	18.69723	21.13162	0.1059
At most 4 *	0.231221	15.25117	14.26460	0.0348
At most 5	0.000153	0.008881	3.841465	0.9246

Max-eigenvalue test indicates 3 cointegrating eqn(s) at the 0.05 level. * denotes rejection of the hypothesis at the 0.05 level. **MacKinnon-Haug-Michelis (1999) p-values.

3. Granger Causality Test

The Granger causality results examine whether changes in price one market predict changes in another. A p-value below 0.05 indicates significant Granger causality, while higher values suggest no evidence of predictive causality. After confirming the integration of prices series, in the next step, pair-wise Granger causality test was performed for six onion markets to comprehend causal relation between them. The results presented in Table 5 illuminates that the most of markets pairs such as Hubballi-Belagavi, Hubballi-Vijayapur, Hubballi-Kolar, Hubballi-Tumakur, Belagavi-Vijayapur, Belagavi-Kolar, Belagavi-Tumakur, Mysore-Tumakur, showed Bi-directional causality. In these situations, the former market in each pair granger causes the latter market's wholesale price formation, which then gives feedback to the former market. The rest of the markets like Hubballi-Mysore Belagavi-Mysore, Kolar-Tumakur, Mysore-Vijayapur, Mysore-Kolar and Vijayapur-Tumakur pairs have unidirectional causality. No causal relationship was found between Kolar and Vijayapur market and vice versa. Different markets of onion were closely linked with each other for the movement of Onion prices which shows long-run relationship with the co-integrating markets.

Table 5: Results of pair wise Granger causality test of onion prices for selected Regional markets of Karnataka

Null Hypothesis:	F-Statistic	Prob.	Directions
Hubballi does not Granger Cause Belagavi	3.50035	0.0027	Bi
Belagavi does not Granger Cause Hubballi	2.15796	0.0490	Bi
Kolar does not Granger Cause Belagavi	5.18377	8.E-05	Bi
Belagavi does not Granger Cause Kolar	27.5186	1.E-21	Bi
Mysore does not Granger Cause Belagavi	1.71245	0.1207	Uni
Belagavi does not Granger Cause Mysore	2.61437	0.0189	Uni
Tumakur does not Granger Cause Belagavi	9.20301	1.E-08	Bi
Belagavi does not Granger Cause Tumakur	20.2978	2.E-17	Bi
Vijayapur does not Granger Cause Belagavi	3.12624	0.0067	Bi
Belagavi does not Granger Cause Vijayapur	17.8340	4.E-15	Bi
Kolar does not Granger Cause Hubballi	3.98811	0.0010	Bi
Hubballi does not Granger Cause Kolar	15.4047	1.E-13	Bi
Mysore does not Granger Cause Hubballi	1.43880	0.2023	Uni
Hubballi does not Granger Cause Mysore	4.46294	0.0003	Uni
Tumakur does not Granger Cause Hubballi	6.69978	2.E-06	Bi
Hubballi does not Granger Cause Tumakur	40.0915	2.E-29	Bi

table cont....

Null Hypothesis:	F-Statistic	Prob.	Directions
Vijayapur does not Granger Cause Hubballi	7.72784	4.E-07	Bi
Hubballi does not Granger Cause Vijayapur	22.4956	2.E-18	Bi
Mysore does not Granger Cause Kolar	6.24119	8.E-06	Uni
Kolar does not Granger Cause Mysore	0.51306	0.7977	Uni
Tumakur does not Granger Cause Kolar	1.25875	0.2812	Uni
Kolar does not Granger Cause Tumakur	11.6562	2.E-10	Uni
Vijayapur does not Granger Cause Kolar	1.42220	0.2117	No
Kolar does not Granger Cause Vijayapur	1.34438	0.2429	No
Tumakur does not Granger Cause Mysore	3.87159	0.0013	Bi
Mysore does not Granger Cause Tumakur	20.4007	2.E-17	Bi
Vijayapur does not Granger Cause Mysore	0.20713	0.9740	No
Mysore does not Granger Cause Vijayapur	4.40104	0.0005	No
Vijayapur does not Granger Cause Tumakur	22.4511	3.E-17	Uni
Tumakur does not Granger Cause Vijayapur	1.20308	0.3098	Uni

CONCLUSION AND POLICY IMPLICATIONS

Onion price volatility creates ripples both in the trade as well as political circles. The increase in onion prices leaves a huge impact on the household food consumption budget, whereas a decrease in prices below the cost of cultivation affects the producer. Therefore, addressing the issue of price volatility of onion is a prime concern for the politicians, policy makers and experts (Paul *et al.,* 2017). The co-integration and price transmission of wholesale onion prices in six major Karnataka marketplaces namely Belagavi, Hubballi, Vijayapur from North Karnataka and Kolar, Mysore, Tumakur from South Karnataka, were investigated in this study. All of the price series in the study state were found to be stationary, indicating that some onion markets were highly integrated and had a long run price relationship. It is seen that, Hubballi and Belagavi market causes the prices of majority of the markets under study in uni-directional manner, these markets emerge as central hubs influencing multiple regions, with strong bidirectional relationships indicating interconnectedness whereas bi-directional causality has been found between few markets pairs. It indicates that Hubballai and Belagavi markets are the dominating market in the price channel. The main reason behind the domination of Hubballi's market is strategic centre location in North Karnataka and adequate infrastructure facilities to convey commodities to large markets and the Belagavi market is a major cross-border trading hub for onions and other perishable items because of its close proximity to Maharashtra and Goa. The results of this study can help build a strong network of wholesale markets throughout the regional markets of state, which will improve price transmission and market integration. One essential element of successful marketing is market integration. Through the Modern infrastructure facility related to agriculture marketing, pricing information systems and transportation facilities, market integration may gradually reduce transportation costs and increase interregional trade. These actions will not only prevent Karnataka's onion production areas from being allocated inefficiently, but they will also improve the efficiency of the state's existing inefficient onion markets. The study recommend for enhancing market integration through infrastructure development and pricing information systems, thereby promoting stability in onion prices and promotion agriculture and economic development.

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