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Market structure and market integration of dry chilli in North Karnataka

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Abstract
The chilli is one of the most important commercial spice crops in India. Despite India's leading role in dry chilli production, minimal research exists on dry chilli pricing and market integration. This study addresses this gap by evaluating price volatility and market integration in key dry chilli markets, focusing on Byadagi, Hubballi and Gadag markets in Karnataka. The study was included both the primary and secondary sources. The primary data for the market structure were mainly gathered from Byadagi market. A random sampling procedure was adopted for selection of commission agents and wholesalers. The required data were collected from 460 commission agents, 403 wholesalers mainly from Byadagi market through pre-tested well-structured schedule during the year 2022-23. Secondary data for market integration was collected from the Byadagi, Hubballi and Gadag markets through Krishi Marata Vahini the official website of KSAMB for the year 2009-10 to 2022-23. The Lorenz coefficient off inequality, Lorenz curve and co-integration technique were employed to analyze the data. Johansen's Multiple Co-integration Test establishes evidence of long-term integration among dry chilli prices in selected markets. Granger causality tests demonstrate unidirectional and bidirectional causal relationships among dry chilli prices in different markets. Reduced form Vector Error Correction estimates highlight the speed of market adjustments to deviations from equilibrium values. With a Gini value of 0.56, the distribution of dry chillies among wholesalers in the Byadagi market from 2022 to 2023 is moderately unequal. From Byadagi to Gadag and from Byadagi to Hubballi, there is unidirectional causality. Additionally, Hubballi and Gadag are causally related in both directions. A one-period lagged change in Byadagi has a coefficient of 0.1302 as shown by D (Byadagi (-1)), indicating that prior changes in Byadagi have a positive influence on its current change. The t-statistic of 1.4521 reflects standard levels of statistical significance.

Keywords: Market integration, concentration, price volatility, granger causality, vector error correction

Introduction
The chilli is one of the most important commercial spice crops in India. The plant known as the chilli is a fruit that is a member of the Solanaceae family and the Capsicum genus. There are more than 400 different varieties of chillies in the world. Cayenne pepper, spicy pepper and pepper are some of its alternate names. Its botanical name is "*Capsicum annuum*". India is the country where "Naga Jolokia," the hottest chilli in the world, is grown.

India is the world's greatest producer, consumer and exporter of chillies. An average of 1.3 to 1.5 million tonnes of red dry chillies is produced in India every year. Only approximately 15 to 20 percent of domestic production in India is exported, while over 80 percent of its output is consumed domestically. In the years 2022–23, when the area was 4.49 million hectares and the production was around 11 metric tonnes, specific spices held a leading position in the production of spices globally. Due to India's diverse environment, which ranges from tropical to sub-tropical and temperate, almost all spices flourish there. In reality, almost all of India's states and union territories grow one or more spices. Currently, dry chillies are used all over the world as a spice, as well as to make drinks and medicines. The chilli crop reached the Asian peninsula in the 16^{th} century thanks to the Portuguese and Spanish explorers' discovery of new sea channels. It swiftly spread throughout all of Asia and indigenous Asians started cultivating this plant as well. Since then, a major amount of chilli output has changed as a result of south Asia's favorable climate for the cultivation of this crop. Although chilli ranks first among Indian spices, there has been very little research on prices and market integration in India. The significance of dry chillies in Indian trade, it is necessary to examine the trends in chilli pricing behaviour. Therefore, the current study was conducted with the goals of evaluating price volatility in important chilli markets and the degree of integration among important chilli markets in Karnataka.

Materials and Methods

The study was included both the primary and secondary sources. The primary data for the market structure were mainly gathered from Byadagi market. A random sampling procedure was adopted for selection of commission agents and wholesalers. The required data were collected from 460 commission agents, 403 wholesalers mainly from Byadagi market through pre-tested well-structured schedule during the year 2022-23. Secondary data for market integration was collected from the Byadagi, Hubballi and Gadag markets through Krishi Marata Vahini the official website of KSAMB for the year 2009-10 to 2022-23. The Lorenz coefficient off inequality, Lorenz curve and co-integration technique were employed to analyze the data.

Lorenz Coefficient of Inequality and Lorenz curve

To gauge the degree of disparity inside the marketing system, one can utilize the Lorenz coefficient of inequality. Between 0 and 1, a lower coefficient denotes a lesser amount of inequality, whereas a higher coefficient shows a greater degree of disparity.

$$L = 1 - \sum_{i=1}^{n} \left[\frac{(x_i - x_{i-1})(y_i + y_{i-1})}{10000}\right]$$

Where,
L = The Lorenz coefficient of inequality
xi = The cumulative percent of agencies upto ith agency
xi-1 =The cumulative percent of agencies upto (i-1)th agency
yi = The cumulative percent of quantity handled upto ith agency
yi-1 = The cumulative percent of agencies upto (i-1)th agency
n = Number of wholesalers or commission agents cum traders
i = Takes value 1, 2, 3, 4, ...n

Seasonal Index

A seasonal index, also known as a seasonal effect or seasonal component, quantifies the relative comparison between a particular season and the overall mean of the cycle.

$$\text{Seasonal index (\%)} = \frac{\text{Monthly average arrivals or prices}}{\text{Average of monthly averages of arrivals or prices}} \times 100$$

Co-integration: in EVIEWS

Co-integration is an analytical method for modelling long-run and short-run dynamics as well as common trends in multivariate time series. When two or more predictive variables in a time-series model have a similar stochastic drift, this is known as co-integration. If a linear combination of the variables results in a stationary time series, the variables are said to be co-integrated. The t-statistics are calculated to determine the significance of the markets both within and between them. If the integration values are larger than 1.96, they are considered significant, otherwise, they are non-significant and will be taken into consideration when drawing conclusions.

Results and Discussion

Concentration of commission agents in Byadagi market (2022-23)

From the Table 1 concentration of commission agents in Byadagi market during the year 2022-23 based on the quantity of commodities they handled. The table is divided into various ranges of quantity handled (in tonnes) by commission agents, with corresponding percentages and cumulative percentages of both the quantity handled of commission agents. The 2.73 percent of the commodities were handled by 5.00 percent of the commission agents (1-23 range). The Lorenz coefficient of inequality for this distribution, denoted as L, is calculated to be 0.53. This coefficient provides a measure of the inequality in the distribution of commodities among commission agents, with higher values indicating greater inequality. In this case, a Gini coefficient of 0.53 suggests a moderate level of inequality, indicating that a significant portion of commodities is concentrated among a relatively smaller percentage of commission agents in the Byadagi market for the year 2022-23.

Table 1: Concentration of Commission agents in Byadagi market during 2022- 23

Commission agents	Quantity handled (tonnes)	Percentage	Cumulative % quantity handled	Cumulative percent in commission agents
1-23	3,050	2.73	2.73	5
23-46	3,500	3.13	5.86	10
46-59	3,950	3.53	9.39	15
59-92	4,800	4.29	13.69	20
92-115	4,980	4.46	18.14	25
116-138	4,980	4.46	22.60	30
138-161	5,050	4.52	27.12	35
161-184	5,100	4.56	31.68	40
184-207	5,800	5.19	36.87	45
207-230	5,800	5.19	42.06	50
231-253	5,800	5.19	47.25	55
253-276	5,810	5.20	52.45	60
276-299	5,980	5.35	57.80	65
299-322	6,100	5.46	63.25	70
322-345	6,110	5.47	68.72	75
345-368	6,570	5.88	74.60	80
368-391	6,690	5.99	80.59	85
391-414	7,000	6.26	86.85	90
414-437	7,200	6.44	93.29	95
437-460	7,500	6.71	100.00	100
Total	1,11,770	100.00		
Lorenz coefficient of inequality, L = 0.53				

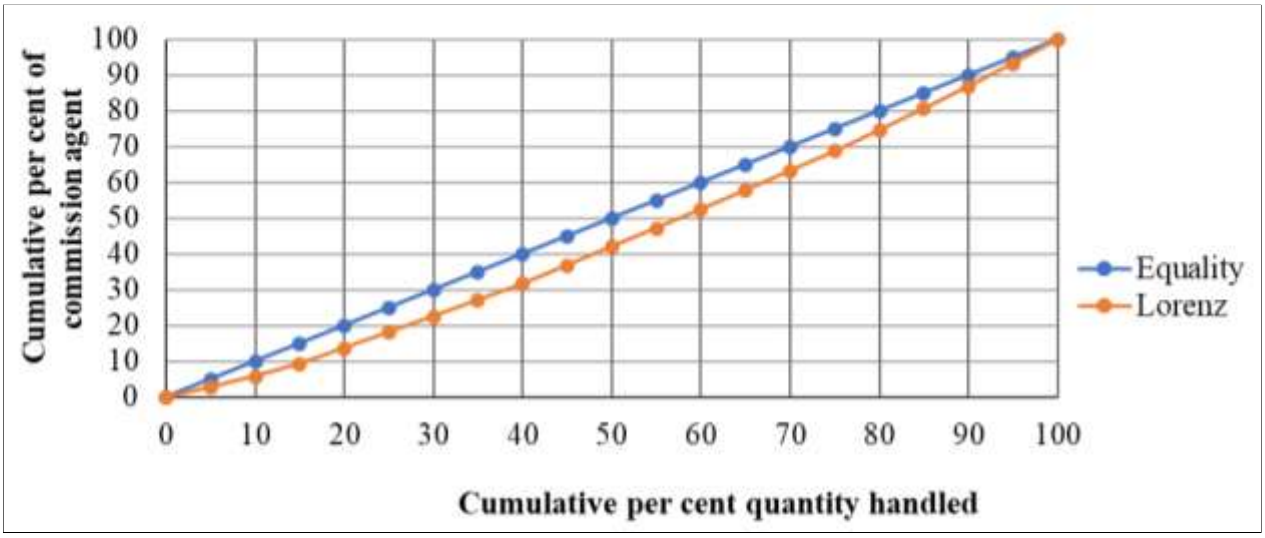

Fig 1: Concentration of commission agents in Byadagi market (2022-23)

Concentration of wholesalers in Byadagi market (2022-23)
Table 2 illustrates the concentration of wholesalers in the Byadagi market for the year 2022-23 based on the quantity of goods they handled. Notably, the data indicates a gradual increase in the quantities handled as we progress through the categories, with the highest category (381-403 tonnes) representing the largest percentage of wholesalers at 7.87 percent. The cumulative percentage of quantity handled provides insight into the distribution of goods across these categories. The Lorenz coefficient of inequality, calculated at 0.56, points to a moderate level of inequality in the distribution of wholesalers based on their handling capacity. This indicates that there is a notable concentration of wholesalers in certain quantity ranges, while others have a more limited presence. This distribution pattern can impact market dynamics, competition and pricing, warranting further examination into its implications for the Byadagi market.

Table 2: Concentration of wholesalers in Byadagi market (2022-23)

Wholesalers	Quantity handled (tonnes)	Percentage	Cumulative % quantity handled	Cumulative % wholesalers
1-20	2,900	2.60	2.59	5
21-40	3,100	2.77	5.37	10
41-60	3,580	3.20	8.57	15
61-80	3,860	3.45	12.03	20
81-100	3,980	3.56	15.59	25
101-120	4,500	4.03	19.61	30
121-140	4,500	4.03	23.64	35
141-160	4,680	4.19	27.83	40
161-180	4,800	4.29	32.12	45
181-200	4,980	4.46	36.58	50
201-220	5,700	5.10	41.68	55
221-240	5,800	5.19	46.86	60
241-260	5,980	5.35	52.21	65
261-280	6,500	5.82	58.03	70
281-300	6,800	6.08	64.11	75
301-320	7,000	6.26	70.38	80
321-340	7,500	6.71	77.09	85
341-360	8,310	7.44	84.52	90
361-380	8,500	7.61	92.13	95
381-403	8,800	7.87	100.00	100
Total 403	1,11,770	100.00		
Lorenz coefficient of inequality, L = 0.56				

Seasonal indices of arrivals and prices of dry chilli in major markets during 2009-10 to 2022-23
Table 3 presents the seasonal indices of arrivals and prices of dry chilli in selected markets from the year 2009-10 to 2022-23. The data is broken down by month and market, including Byadagi, Hubballi and Gadag markets. In the Byadagi market, the highest arrivals of dry chilli are typically observed in January, with a seasonal index of 265.60, while the lowest arrivals occur in June with a seasonal index of 22.02. On the other hand, the highest prices are recorded in December with a seasonal index of 112.15, while the lowest prices are found in April with a seasonal index of 99.04. In the Hubballi market, February witnesses the highest arrivals with a seasonal index of 276.30, while June has the lowest arrivals with a seasonal index of 12.01. Prices in Hubballi are at their peak in December with a seasonal index of 128.92 and lowest in May with a seasonal index of 83.91. In the Gadag market, September shows the highest arrivals with a seasonal index of 54.58, while June records the lowest arrivals with a seasonal index of 38.92. Prices in Gadag are highest in September with

a substantial seasonal index of 178.25, while the lowest prices are seen in April with a seasonal index of 84.19.Overall, these seasonal indices provide valuable insights into the patterns of dry chilli arrivals and prices across these markets, helping stakeholders make informed decisions based on seasonal trends.

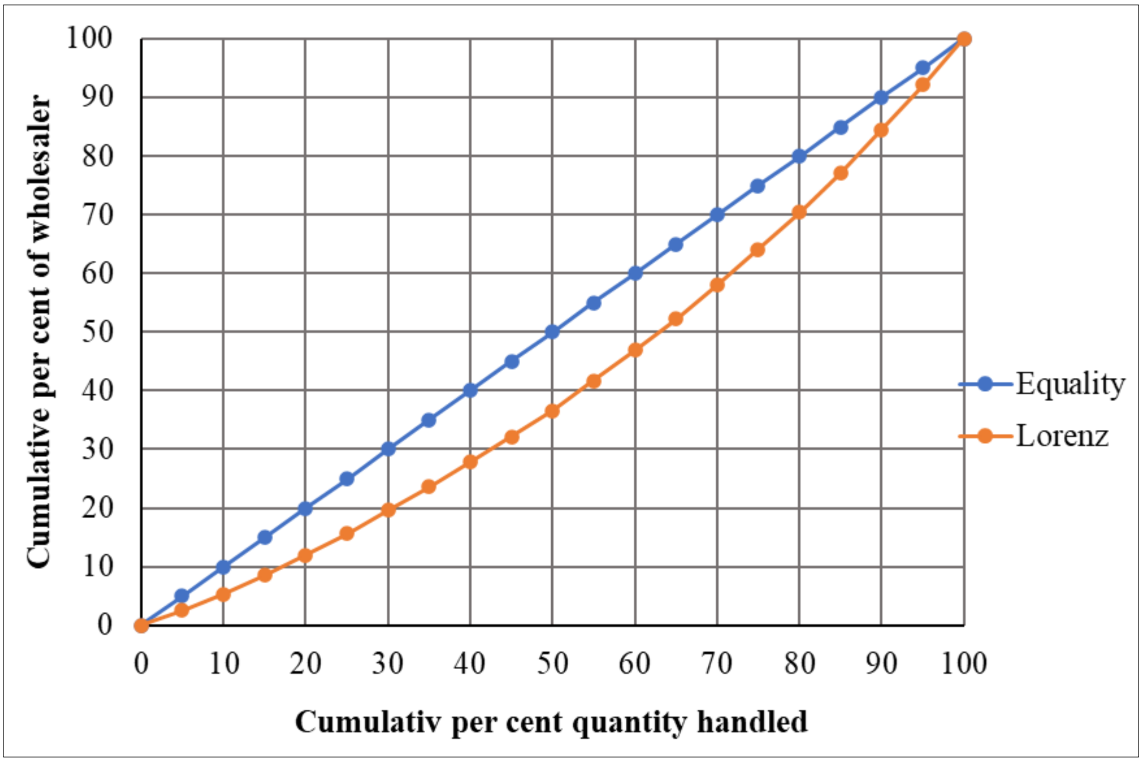

Fig 2: Concentration of wholesalers in Byadagi market (2022-23)

Table 3: Seasonal indices of arrivals and prices of dry chilli in selected markets (2009-10 to 2022-23)

Month	Byadagi market		Hubballi market		Gadag market	
	Arrivals	**Prices**	**Arrivals**	**Prices**	**Arrivals**	**Prices**
January	265.60	106.56	262.71	129.46	231.80	112.71
February	255.17	105.82	276.30	109.99	179.78	113.58
March	260.35	102.76	254.17	108.31	213.54	96.37
April	157.50	99.04	160.94	99.59	100.86	84.19
May	44.73	95.79	49.34	83.91	38.92	78.73
June	22.02	94.87	12.01	83.48	38.92	85.64
July	17.83	94.80	10.48	90.68	32.96	83.37
August	14.93	94.89	9.13	88.20	50.83	82.51
September	16.30	96.50	10.13	87.21	54.58	178.25
October	16.77	96.01	10.77	89.92	45.29	82.99
November	34.15	100.82	18.81	100.33	50.88	96.34
December	94.64	112.15	125.19	128.92	161.63	105.31

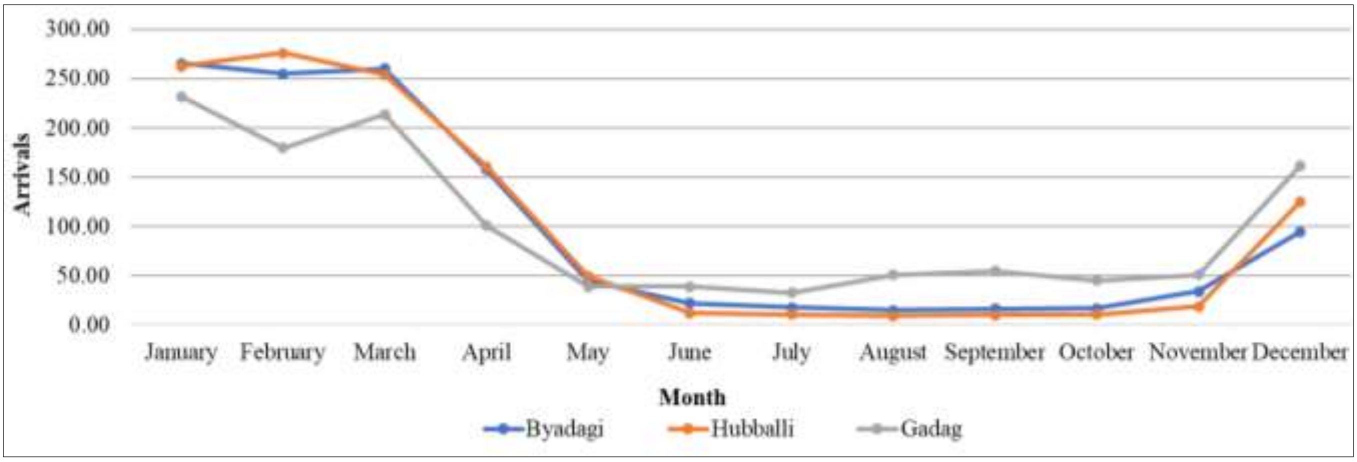

Fig 3: Seasonal indices of arrivals of dry chilli in selected markets

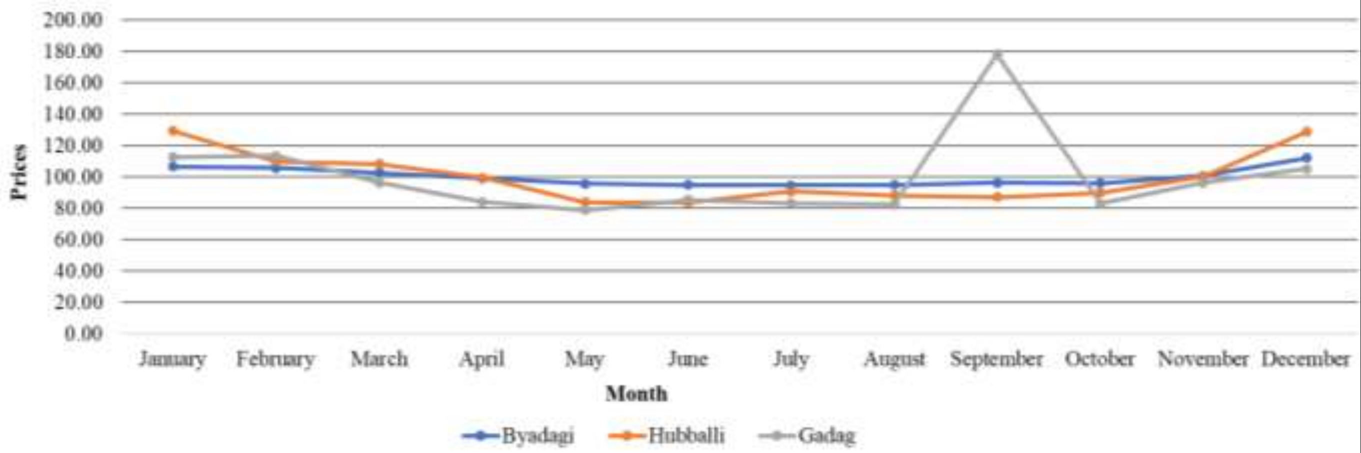

Fig 4: Seasonal indices of prices of dry chilli in selected markets (2009-10 to 2022-23)

Results of stationary test for Byadagi dry chilli in selected markets of Karnataka

Table 4 In the case of Byadagi dry chilli, the level of the variable shows a test statistic of -2.802819 with a corresponding p-value of 0.1984. This result indicates that at the level, the data may not be stationary. However, when examining the first differences of the variable, the test statistic is -10.9303 and the associated p-value is 0.0000 indicating significance at the 1 percent level. This suggests that the first differences of Byadagi dry chilli data are stationary, which is crucial for co-integration. For Gadag, the level of the variable demonstrates a highly significant result with a test statistic of -12.02324 and a p-value of 0.0000, signifying strong evidence of stationarity at the level. Similarly, when looking at the first differences, the test statistic is -9.7877, with a p-value of 0.0000, indicating stationarity in the first differences. These results emphasize the stationarity of the Gadag dry chilli data, which is favorable for accurate time series analysis. Similarly in the case of Hubballi market, at the level, the test statistic is -3.232088 with a p-value of 0.0818, suggesting that the data may not be stationary at this level. However, when focusing on the first differences, the test statistic is -14.1350 and the p-value is 0.0000, signifying stationarity in the first differences. This implies that the first differences of Hubballi dry chilli data are stationary, allowing for reliable time series analysis and modeling. The results of the stationary tests for Byadagi, Gadag and Hubballi dry chilli data indicate that while the levels of the variables may not be stationary, the first differences are stationary in all cases. This stationarity is crucial for accurate time series analysis and forecasting, making these findings significant for researchers and analysts studying dry chilli markets and their dynamics.

Table 4: Results of stationary test for Byadagi chilli in selected markets of Karnataka

Variable	Level	P-value	First difference	P-value
Byadagi	-2.802819	0.1984	-10.9303	0.0000**
Gadag	-12.02324	0.0000	-9.7877	0.0000**
Hubballi	-3.232088	0.0818	-14.1350	0.0000**

Note: ** Significant at 1 percent level

Long term integration of dry chilli prices in selected markets of Karnataka

The table 5 provides trace statistics for the three series, indicating the number of common co-integrating equations (CE) along with their respective eigen values, statistics, critical values and probabilities. In this analysis, the null hypothesis assumes that there are no co integrating equations (None). However, the data shows that the eigen value associated with this hypothesis is 0.3535, resulting in a statistic of 87.6234. The critical value at the 0.05 level, based on MacKinnon (1999), is 24.2760. Importantly, the probability associated with this result is 0.0000indicating strong evidence against the null hypothesis of no co-integration. Therefore, it can be concluded that there is co-integration among the dry chilli prices in the selected markets. The next hypothesis considered is "At most 1," suggesting that there is at most one co-integrating equation. The associated eigen-value is 0.0819, with a statistic of 15.6519. The critical value at the 0.05 level is 12.3209. However, the probability is 0.0133which means that this hypothesis can be rejected at the 0.05 level. This indicates that there is at least one co-integrating equation among the dry chilli prices in these markets. The final hypothesis "At most 2" suggests that there are at most two co-integrating equations. In this case, the eigen value is 0.0094, resulting in a statistic of 1.5621. The critical value at the 0.05 level is 4.1299. However, the probability associated with this result is 0.2480, which is above the 0.05 significance level. Thus, this hypothesis is not rejected, indicating that there may not be more than two co-integrating equations among the dry chilli prices.

The results of Johansen's Multiple Co-integration Test suggest that there is evidence of co-integration among the dry chilli prices in the selected markets of Karnataka. This indicates a long-term relationship between these prices, which can be valuable for understanding price dynamics, market interactions and making informed decisions in the dry chilli trade.

Table 5: Long term integration of dry chilli prices in selected markets of Karnataka (Johansen's multiple co-integration Test)

Trace statistics of Series Byadagi, Gadag and Hubballi				
No. of CE(s)	Eigenvalue	Statistic	Critical value	Probability
None *	0.3535	87.6234	24.2760	0.0000*
At most 1*	0.0819	15.6519	12.3209	0.0133*
At most 2	0.0094	1.5621	4.1299	0.2480

Note: Trace test indicates 2 cointegrating eqn(s) at the 0.05 level.
* Denotes rejection of the hypothesis at the 0.05 level.
Critical values based on MacKinnon (1999).

Pair wise direction of dry chilli prices in selected markets of Karnataka

Table 6 presents the results of Granger causality tests, which are essential for assessing the pair wise direction of influence among dry chilli prices in selected markets of Karnataka, including Byadagi, Gadag and Hubballi. Starting with the null hypothesis that "Gadag does not Granger cause Byadagi" the F-statistic is 2.4780 with a corresponding p-value of 0.0871. While this result suggests potential causality, it is not significant at conventional levels. However, when testing the reverse hypothesis, "Byadagi does not Granger Cause Gadag," the F-statistic is 13.2360 and the p-value is 0.0000 indicating strong evidence of Granger causality. This implies that past prices of Byadagi significantly influence future prices in Gadag, indicating a unidirectional causal relationship. Moving on to the relationship between Hubballi and Byadagi, the null hypothesis "Hubballi does not Granger Cause Byadagi" yields an F-statistic of 1.2097 and a p-value of 0.3010, which is not significant. However, the reverse hypothesis, "Byadagi does not Granger Cause Hubballi," shows an F-statistic of 7.2336 and a p-value of 0.0010 signifying a significant Granger causal relationship from Byadagi to Hubballi in a unidirectional direction. Finally, examining the interaction between Hubballi and Gadag, the null hypothesis Hubballi does not Granger Cause Gadag results in an F-statistic of 6.5140 and a p-value of 0.0019 indicating significance. Likewise, the reverse hypothesis, Gadag does not Granger Cause Hubballi, shows an F-statistic of 9.8264 and a p-value of 0.0000 both marked with double asterisks, signifying a significant bidirectional Granger causal relationship between Hubballi and Gadag.

In summary, the Granger Causality tests reveal various causal relationships among the dry chilli prices in these selected markets of Karnataka. Specifically, there is unidirectional causality from Byadagi to Gadag and from Byadagi to Hubballi. Additionally, there is bidirectional causality between Hubballi and Gadag. These findings provide valuable insights into how past prices in one market influence future prices in another, aiding traders, analysts and policymakers in understanding the dynamics of dry chilli prices in the region.

Table 6: Pair wise direction of dry chilli prices in selected markets of Karnataka

Null hypothesis	F-statistic	P–value	Direction
GADAG does not Granger Cause BYADAGI	2.4780	0.0871	Unidirectional
BYADAGI does not Granger Cause GADAG	13.2360	0.0000**	
HUBLI does not Granger Cause BYADAGI	1.2097	0.3010	Unidirectional
BYADAGI does not Granger Cause HUBLI	7.2336	0.0010**	
HUBLI does not Granger Cause GADAG	6.51404	0.0019**	Bidirectional
GADAG does not Granger Cause HUBLI	9.8264	0.0000**	

Note: ** Significant at 1 percent level

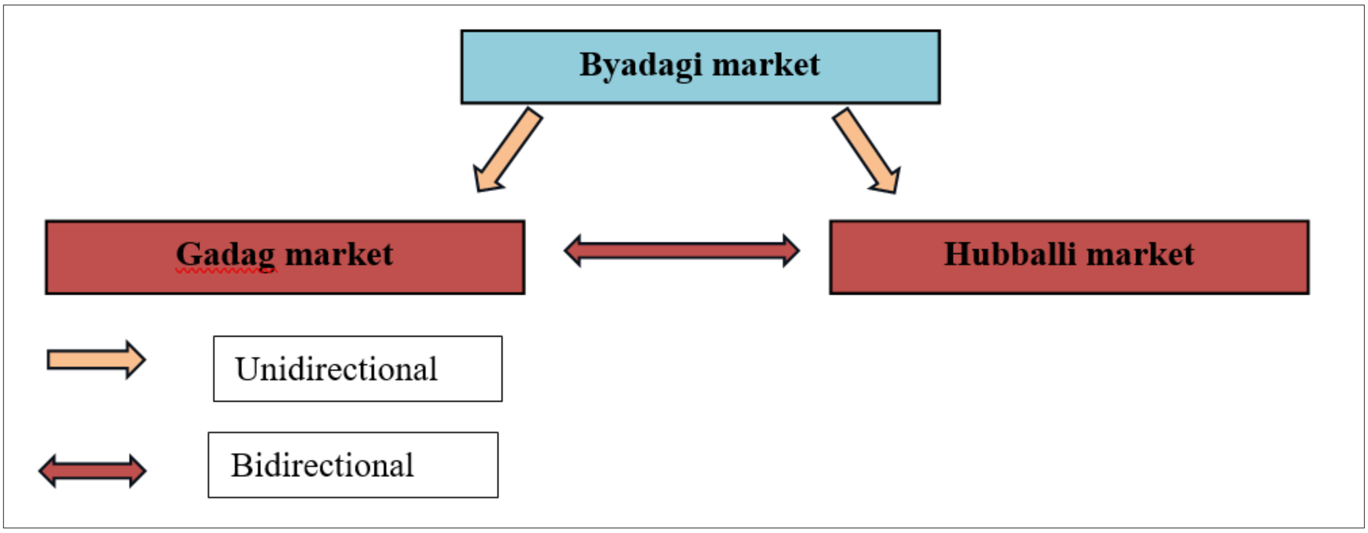

Fig 5: Pairwise direction of dry chilli prices in selected markets of Karnataka

Reduced form vector error correction estimates for dry chilli markets

Table 7 provides the results of the reduced form vector error correction estimates for the dry chilli markets, specifically Byadagi, Gadag and Hubballi.

The error correction coefficients indicate the speed of adjustment of each market to deviations from their long-term equilibrium. In the case of Byadagi, the coefficient is -0.0239, which is statistically significant at the 1 percent level with a t-statistic of -1.7731. This implies that when Byadagi deviates from equilibrium, it corrects itself by about 2.39 percent in the next period. Similarly, Gadag has a coefficient of 0.7169, indicating a strong and positive correction of about 71.69 percent in response to deviations from equilibrium. Hubballi also exhibits correction, with a coefficient of -0.1464. The lagged differenced values of Byadagi, Gadag and Hubballi are represented in the subsequent rows. For instance, D (Byadagi (-1)) shows that a one-period lagged change in Byadagi has a coefficient of 0.1302, suggesting that past changes in Byadagi positively impact its current change. The t-statistic of 1.4521 indicates statistical significance at conventional levels. The coefficients for other lagged values of Byadagi, Gadag and Hubballi follow similar interpretations. They reflect the short-term relationships and adjustments between these markets based on their past values.

The Reduced Form VEC estimates provide valuable insights into the dynamic relationships and adjustments between the dry chilli markets in Karnataka. These coefficients offer information on how these markets respond to short-term deviations from their long-term equilibrium values, aiding traders and analysts in understanding market dynamics and making informed decisions.

Table 7: Reduced form Vector Error Correction estimates for dry chilli markets.

Error Correction:	D(BYADAGI)	D(GADAG)	D(HUBLI)
CointEq1	-0.0239	0.7169	-0.1464
	[-1.7731]	[7.2317]	[-5.1169]
D (BYADAGI (-1))	0.1302	-0.7137	0.7384
	[1.4521]	[-1.0819]	[3.8778]
D (BYADAGI (-2))	-0.0494	-0.9548	-0.0570
	[-0.5204]	[-1.3665]	[-0.2827]
D (GADAG (-1))	-0.0126	0.0261	-0.1982
	[-0.8068]	[0.2279]	[-5.9930]
D (GADAG (-2))	-0.01357	0.0031	-0.1077
	[-1.1838]	[0.0363]	[-4.4271]
D (HUBLI (-1))	0.0084	0.0185	-0.2533
	[0.2232]	[0.0666]	[-3.1618]
D (HUBLI (-2))	0.0028	0.0743	-0.0856

Conclusion

The chilli is one of the most important commercial spice crops in India. The plant known as the chilli is a fruit that is a member of the Solanaceae family and the Capsicum genus. There are more than 400 different varieties of chillies in the world. Many researches have been examined price transmission and market integration of dry chilli in Haveri district, while relatively few studies there are market integration of dry chilli. Mostly previous study assessed the information to what extents and to which markets prices are transmitted across spatially different markets. However, there is scarce literature that determines the factors influence market integration in north Karnataka. Thus, the analysis of market integration remains weak without further analysis on factors that explain such of market integration or segmentation. In addition, special attention needs to be paid to the importance of transaction cost in the market integration analysis. Therefore, the research data has to be collected by surveying the real transport cost in the locations. Thus, in further studies other analytical tools need to be employed such as threshold cointegration model approach which consider to include transportation cost in the market integration analysis. From byadagi to Gadag from Byadagi to Hubballi, there is unidirectional causality. Additionally, Hubballi and Gadag are causally related in both directions.

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