JENRM, Vol. 3, No. 2, 37-43, 2017
Research Article

Integration of Cumin markets in Rajasthan

Richard Kwasi Bannor [*], Madhu Sharma [**], Surjeet Dhaka [***]

Abstract
The study investigated the integration between cumin (Cuminum cyminum) markets pairs in Rajasthan State using monthly cumin price series of five (5) markets from 2008-2015. The co-integration tests results indicate Nagaur and Pali; Nagaur and Jodhpur; Nagaur and Jalore markets are integrated in the long run at lag five (5). However, the rest of other market pairs are not integrated in the long run. The results from the error correction model showed that, the lowest speed of adjustment towards long run equilibrium was from Nagaur to Jalore market at rate of 37.4%. The highest speed of adjustment was 56.6%, running Nagaur to Pali market towards long run equilibrium. This is followed by a speed of adjustment of 45.1% running from Nagaur to Jodhpur market towards along run equilibrium in a period of at most one (1) month. The results further indicate bidirectional causality between Nagaur and Pali markets and also Naguar and Jalore markets. There is also a unidirectional causality of price change from Merta City market of Nagaur to Bhagat Ki Kothi market of Jodhpur but not vise versa. The results from the unrestricted vector autoregressive (VAR) model was run for market pairs that were not cointegrated that cumin price series between Ajmer and Jodhpur; Jodhpur and Pali and Jodhpur and Jalore Granger causes each other in the short run whereas Ajmer Granger causes Nagaur, Pali and Jalore in less than one month though in the long run they drift apart. The study further reveal that orthogonalized shock or unexpected shocks to Nagaur market will result in permanent effect on the prices of other selected markets within one year. In the same way, unexpected shock to market prices of Pali will result in permanent price effect on Nagaur cumin prices but temporary on prices in Jodhpur. On the other hand unexpected shock to prices of Ajmer will results in transitory or temporary price effect on prices in Pali, Nagaur, Jodhpur and Jalore markets.

Keywords
Cumin—ECM—Market Integration—Rajasthan—VAR

[*]Zenith University College, Accra- Ghana, Email:etwienana@gmail.com
[**]Institute of Agribusiness Management, SK Rajasthan Agricultural University, Bikaner-India, Email: madhu@iabmbikaner.org
[***]Institute of Agribusiness Management, SK Rajasthan Agricultural University, Bikaner-India, Email: surjeetdhaka.iabm@gmail.com

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1. Introduction

Production of spices in India is a little over 5.9 million metric tonnes which is spread over an area of about 3.2 million hectares in 2013-2014 production years. Out of these, Rajasthan total production is about 674800 metric tonnes over an area of about 819500 hectares. India, is not only the world leader in the context of spice production, but also the largest producer of cumin in the world with total production of cumin of about 513850 metric tonnes which is spread over an area of 856900 hectares in 2013-2014 (Anonymous, 2015; National Horticulture Board, 2014). The total contribution of (Cuminum cyminum) which is short-term major spice crop to the total amount of spices produced in the country was 8.70% during the 2013-2014 production years.

Gujarat and Rajasthan are the major producers of (Cuminum cyminum) in the country. About 45.5 percent of cumin produced in the country in 2013-2014 was from Rajasthan which is represented by 233820 metric tonnes (National Horticulture Board, 2014).

The Government of India, Rajasthan Government and other sanctioned spice bodies in the country underscores the importance of cumin in the diet of the population and the livelihood of farmers in Rajasthan and Gujarat. In line with this, many researches have gone into production of cumin by these recognised bodies. Case in point is agricultural universities in Rajasthan and Gujarat have introduced improved varieties of cumin such as S-404, MC-43. Gujarat Jeera-1 (GC-1), GC-2, GC-3, RS-1, UC-198, RZ-19, etc., which have higher yield potential. The National Research Centre on Seed Spices, Tabiji, has also undertaken a lot of research on improving production of cumin especially in Rajasthan. The researches ranges from better water management practices; cultivation of seed spice crops on raised beds coupled with drip and sprinkler system to cropping sequence models specifically for cumin (Anonymous, 2014).

In addition several researches have been undertaken by scientist in many ways to improve production and other production related issues of cumin; Lal et al., (2015), Singh (2015); Lal et al., (2013); Kumawat et al., (2011); Meena and Singh (2011); Mehriya et al., (2007) and Singh and Rao (2006) just to mention a few.

However, to the best of the knowledge of the researchers and literature review, though marketing is critical as production, so far as cumin is concern, no research has been conducted to determine the extent to which cumin markets in Rajasthan are integrated or otherwise. This is crucial because, efficient marketing system or integration of cumin markets is a critical pre requisite for rapid increase in cumin production and to reap maximum possible benefits from farming as sought by the production researches. It is unequivocally clear that, no farmer will put in extra labour and work to produce surplus or even continue to produce cumin against other potential spices and other arid legumes like guar in the state unless assured of remunerative prices and margins through efficient marketing system (Bannor,2015). Thus, an efficient agricultural marketing system is vital to provide incentive to farmers to produce more and attain higher productivity of cumin. Hence, examining how cumin markets are integrated in the state will help government and its agencies such as the Ministry of Agriculture, Rajasthan Horticultural Board and various stakeholders of cumin in the country and the state alike to undertake actions or directions which can push the cumin industry in the state.

2. Methodology

2.1 Sources of data

The secondary data used for this study was sourced from AGMARKNET database (from http://agmarkweb.dacnet.nic.in/sa_reports_menu.aspx). This database is under the directorate of Marketing and Inspection of the Ministry of Agriculture of Government of India. Data set of five (5) markets namely Sojat road at Pali, Merta City at Nagaur, Kekri at Ajmer, Bhagat Ki Kothi at Jodhpur and Bhinmal at Jalore of Rajasthan were sourced, covering monthly cumin prices and arrivals from January 2008 to September 2015. The markets represent highest arrivals and highest trading markets of cumin in Rajasthan.

2.2 Method of data analysis

Trend analysis, seasonality indices, growth rate models or log linear model, unit root test, co-integration technique (Johansen co-integration test), error correction and vector autoregressive models were used in the anlaysis. The market integration approach adopted by the researchers was shaped by Bannor, 2015; Mafimisebi et al., 2014; Kwasi and Kobina, 2014; Kwasi, 2015.

Unit root test: A stationary series or series with no unit root is one with a mean value which will not vary with the sampling period. In contrast, a non-stationary series will exhibit a time varying mean (Juselius, 2006). Before examining integration relationships between or among markets, the researchers tested for unit root or non stationarity of the data set using Augmented Dickey Fuller and DF-GLS test. It was necessary to avoid spurious and misleading regression estimates. The framework of ADF methods is based on analysis of the following model

$$\Delta\rho_t = \alpha + \beta\rho_{t-1} + \gamma T + \sum_{k=1}^{n} \delta_k \Delta\rho_{t-k} + U_t .....(1)$$

Here, ρ_t is the cumin price series being investigated for stationarity, λ is first difference operator, T is time trend variable, μ_t represents zero- mean, serially uncorrelated, random disturbances, k is the lag length; α, β, γ and δ_k are the coefficient vectors. Unit root tests were conducted on the β parameters to determine whether or not each of the cumin market series is more closely identified as being I(1) or I(0) process.

Testing for Johansen co-integration (trace and eigen value tests): After establishing two cumin market price series are individually stationary at same order, the Johansen co-integration model was used to estimate the long run co-integrating vector using a Vector Auto regression (VAR) model of the form:

$$\Delta\rho_t = \alpha \sum_{i=1}^{k-1} \Gamma i \Delta\rho_{t-1} + \mu_t ....(2)$$

Where $\Delta\rho_t$ is a nx1vector containing the series of interest (the three variable series) at time (t), is the first difference operator Γi and are nxn matrix of parameters on the ith and kth lag of

$$\rho_t, \Gamma i = [\sum_{i=1}^{k} A_i] - I_g, \Pi = \sum_{i=1}^{k} A_i - I_g ....(3)$$

Ig is the identity matrix of dimension g, is constant term, μt is nx1 white noise error vector. Throughout, p is restricted to be (at most) integrated of order one, denoted I(1), where I(j) variable requires jth differencing to make it stationary. Johansen and Juselius (1990) and Juselius (2007) derived two maximum likelihood statistics for testing the rank of Π, and for identifying possible co-integration as the following equations show:

$$\lambda_{trace}[r] = -T \sum_{i=r+1}^{m} In(1-\lambda_i) ....(4)$$

$$\lambda_{max}[r, r+1] = -T In(1-\lambda_{r+1}) ....(5)$$

Where r is the co-integration number of pair-wise vector, λt is ith eigen value of matrix Π. T is the number of observations. The λ_{trace} is not a dependent test, but a series of tests corresponding to different r-value. The λ_{max} tests each eigen value separately. This model was used to test for; (1) integration between various cumin market price series of Rajasthan.

Test for Granger-Causality: After undertaking co-integration analysis of the long run linkages of the various market pairs, and having identified they are linked, an analysis of statistical causation was conducted. The causality test uses an error correction model (ECM) of the following form;

$$[\rho_j i = \beta_0 + \beta_i pi(t-1) + \beta_2 pj + \sum_{k=1}^{m} \delta_k \Delta \rho i(t-k) + \sum_{h-1}^{n}$$

$$\Delta\sigma\Delta_h h \Delta pj(t-h) + \mu_t]$$

Where m and n are number of lags determined by Akaike Information Criterion (AIC).If the null hypothesis that say Merta City in Nagaurcumin market pricesinRajasthan j do not Granger cause Kekri market in Ajmer cumin market prices in Rajasthan i is rejected (by a suitable F-test) that $\sigma h = 0$ for h = 1, 2. . . .n and β=0, this indicates Merta City cumin market price j Granger-cause Kekri cumin market prices in Rajasthan i.

2.3 Impulse response function

Impulse response function is a shock given to both VAR and ECM models used in the analysis. Impulse responses identify the responsiveness of the dependent variable in the models when a shock is put to the error term. A simplified model of impulse response function for Merta City against Kekri Market market prices can be written as:

$$MertaCity_t = B_0 + B_1 Kekri_{t-1} + ... + B_h$$

$$MertaCity_{t-h} + U_t ....(7)$$

Where U_t is error term or shock or impulse. Hence the model will give us the effect on the VAR system when a unit shock is applied to variables.

3. Results and Discussion

Source: Authors own computation base on price series data from 2008-2015

Figure one (1) shows trend of cumin monthly prices per quintal over a period of January 2008 to September 2015. The trend of prices shows a steady increase in prices over the study period. The lowest price of 4855 rupees per quintal of cumin was recorded in Merta city market of Nagaur in November 2011 whereas the highest price of 15938 rupees per quintal was recorded in Bhinmal market of Jalore in June 2015. Generally the trend shows, prices of cumin in various markets were low during the 2014 production year.

The results from table one shows that cumin prices over the years from 2008 to 2015 have been less volatile.

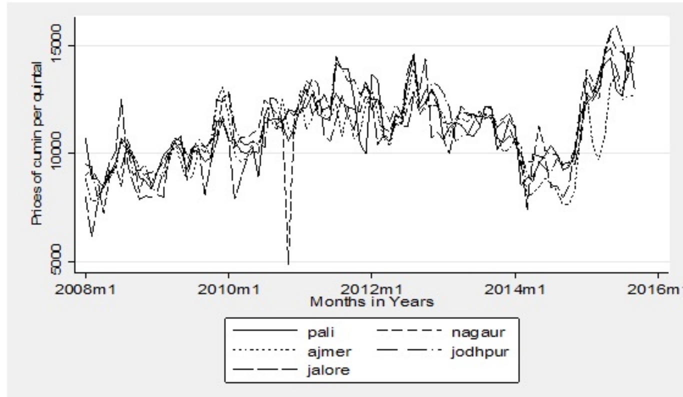

Figure 1. Trend of cumin prices in selected markets of Rajasthan

Table 1. Price volatility of cumin in selected markets of Rajasthan, 2008-2015

Years	Pali	Nagaur	Ajmer CoV (%)	Jodhpur	Jalore
2008	9.19	9.48	9.36	6.53	18.3
2009	7.33	7.98	13.53	11.48	12.51
2010	7.47	18.87	8.01	8.26	13
2011	10.81	3.8	6.12	5.95	8.32
2012	9.55	5.14	8.08	6.98	10.18
2013	5.33	1.85	5.63	5.45	6.78
2014	9.68	8.82	13.47	6.26	11.46
2015	6.4	6.1	11.54	4.75	9.18
2006-2015	14.32	15.15	14.39	15.22	18.25

*Coefficient of Variation (CoV)

The highest volatility of prices was 18.87 percent in Merta City market of Nagaur during the 2010 production year however the lowest volatility was 1.85 percent during 2013 production in year also in Merta City of Nagaur. Generally agriculture products are very volatile however year by year comparison of cumin prices shows less volatility which is a strong sign of tentative cumin markets integration in Rajasthan.

Table 2. Rate of growth of prices in selected cumin markets in Rajasthan, 2008-2015

Markets	Coefficient	RSE	T value	P>(t)	R square
Pali	0.002354	0.00049	4.81	0	0.2
Nagaur	0.003082	0.000533	5.79	0	0.25
Ajmer	0.001334	0.000627	2.13	0.036	0.59
Jodhpur	0.002482	0.000569	4.37	0	0.19
Jalore	0.00331	0.000735	4.5	0	0.23

*Robust Std. Error (RSE)

Table 2 shows growth rate of prices in selected markets of cumin in Rajasthan. The results show the yearly increase of prices over the study period (2008-2015). The table shows that the growth rate of prices from 2008-2015 was 0.234%, 0.308%, 0.133%, 0.248% and 0.331% for Pali, Nagaur, Ajmer, Jodhpur and Jalore markets respectively. The highest growth rate of prices was recorded in Bhinmal market of Jalore and the lowest was recorded in Kekri market of Ajmer. Generally the growth rate of prices has been almost similar for all the markets during the study period which could be a positive influence on market integration.

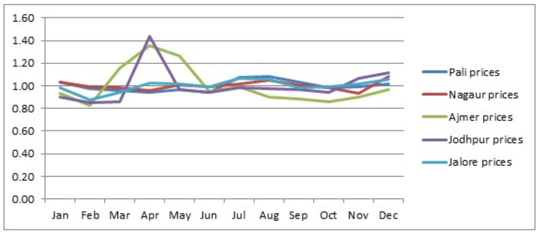

Figure 2. Graphical representation of seasonality indices of cumin prices in selected markets

Source: Authors own computation The seasonality indices graphical representation shows that cumin prices are high during April to June in Ajmer and Jodhpur markets. The prices are low during the month of March in Bhagat Ki Kothi market of Jodhpur; October in Kekri market of Ajmer; February in Bhinmal market of Jalore and November in Merta City market of Nagaur.

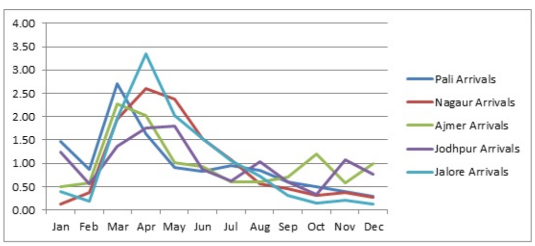

Figure 3. Map Showing the Location of Tarkwa.
Source: Authors own computation

Figure 3 indicates that cleary arrivals in selected markets peak from March to April. After these periods arrivals start decreasing till it hit low in July for Kekri market of Ajmer and September to December for the other selected major markets.

Table 3. Unit root testing

Variables	PL 1(0) Intercept with Trend	
Markets	ADF Stats CV=-3.461	DF-GLS T. Stats CV=-3.052
	T. Stats	T. Stats
Pali	-2.554	-2.625
Nagaur	-2.994	-2.967
Ajmer	-2.511	-2.248
Jodhpur	-2.549	-2.372
Jalore	-2.397	-2.322

*Test Statistics (T. Stats) *Price Level (PL)

- Ho: variables are not stationary or has unit root
- H1: Variables are stationary or does not have unit root
- NB: If the absolute value of ADF and DF-GLS Test Statistics is less than their 5% critical value we accept null hypothesis. It is also when the MacKinnon approximate p-value for Z(t) is insignificant.

The study first examined each market time series for evidence of non-stationarity in order to proceed with co-integration, VAR and ECM analysis of the data prices data set. At level (0), all the selected cumin market price series in Rajasthan were not stationary. DF-GLS test and Augmented Dickey Fuller showed similar results of non stationarity. When price series are non-stationary, one cannot proceed with cointegration, VAR and ECM models as it will produce spurious regression results.

Table 4. Unit root testing at first difference

Variables	F. Diff. 1(1) Intercept with trend	
Market prices	ADF Stats CV=-3.462	DF-GLS T. Stats CV=-3.052
	T. Stats	T. Stats
Pali	-6.524	-3.198
Nagaur	-7.494	-7.471
Ajmer	-6.876	-4.983
Jodhpur	-5.662	-5.631
Jalore	-5.533	-3.56

*Test Statistics (T. Stats) *First Difference (F. Diff.)
Source: Author's computation from time series data analysis

- Ho: variables are not stationary or has unit root
- H1: Variables are stationary or does not have unit root
- NB: If the absolute value of ADF and DF-GLS Test Statistics is greater than their 5% critical value we reject null hypothesis. It is also when the MacKinnon approximate p-value for Z(t) insignificant.

The study went further to test the unit root in the selected market price series at first difference. Thus, the researchers difference each of the price series and tested again for stationarity. DF-GLS test and Augmented Dickey Fuller showed similar results as indicated in table 6 that all the market price series prices are stationary at first difference.

At rank 0: Ho: There is no co-integration between the variables H1: There is co-integration between the variables NB: We accept null hypothesis when trace statistics is less than the 5% Critical value at rank 0. At rank 1: Ho: There is (1) co-integration of the variables at rank 1 H1: There is no (1) co-integration of the variables at rank 1. NB: We accept null hypothesis when trace statistics is less than the 5% Critical value at rank 1. The co-integration tests results as showed in the table 5,

Table 5. Co-integration results for market pairs

Market Pairs	T. Stats	5% C. Value	No. lags	Rank	Remarks
Nagaur ↔ Pali	3.43 *	3.76	5	Rank 1	Co-int
Nagaur ↔ Ajmer	10.85	15.41	5	Rank 0	No Co-int
Nagaur ↔ Jodhpur	3.14*	3.76	5	Rank 1	Co-int
Nagaur ↔ Jalore	2.17*	3.76	5	Rank 1	Co-int
Ajmer ↔ Pali	11.72	15.41	7	Rank 0	No Co-int
Ajmer ↔ Jodhpur	14.59	15.41	11	Rank 0	No Co-int
Ajmer ↔ Jalore	6.83	15.41	11	Rank 0	No Co-int
Jodhpur ↔ Pali	10.6	15.41	11	Rank 0	No Co-int
Jodhpur ↔ Jalore	10.99	15.41	11	Rank 0	No co-int

*Trace Statistics (T. Stats) *Critical Value (C. Value)
*Co-integration (Co-Int)

indicate, Nagaur and Pali; Nagaur and Jodhpur; Nagaur and Jalore markets are integrated in the long run at lag five (5). i.e. there is long run relationship between these two markets hence the prices of the market pairs move together in a period of at most one (1) month. However, the rest of other market pairs are not integrated in the long run.

Table 6. Vector Error Correction (VECM) Model results for the co integrated variables

Market Pairs	P Value	EC Term	SRM/C	SRCR	
			Prob>Chi	Direction	
Nagaur ↔ Pali	3.43 *	3.76	5	Rank 1	Co-int
Nagaur → Jodhpur	0.046	-0.451	0.000*, 0.201	Unidir	Short run
Nagaur ↔ Jalore	0.054	-0.374	0.000*, 0.020*	Bidir	Short run

*Error Correction (EC) *Short run model/Causality (SRM/C)
*Short run Causality Remarks (SRCR) *Unidirectional (Unidir)
*Bidirectional (Bidir)
*Source: Author's computation

$A \leftrightarrow$ B=Bidirectional, A→B=A causes B, A←B=B causes A,*= Sign. Ho: No short run causality running from variable A to B H1: Short run causality running from A to B or variable A causes changes in variable B in the short run NB: Reject null hypothesis when the Prob> chi value is <5%

The error correction model was used to analyse the markets pairs that were co-integrated in the long run. The results from the error correction model showed that, the lowest speed of adjustment towards long run equilibrium was from Nagaur to Jalore market at rate of 37.4%. The highest speed of adjustment was 56.6%, running Nagaur to Pali market towards long run equilibrium. This is followed by a speed of adjustment of 45.1% running from Nagaur to Jodhpur market towards along run equilibrium in a period of at most one (1) month. Generally there is low to medium speed of adjustment towards long run equilibrium within a period of 1 month between integrated market pairs. The results further indicate bidirectional causality between Nagaur and Pali markets and also Nagaur and Jalore markets. Thus, a price change in Nagaur or Pali markets will result in less than one month price change in the other market pair. There is a unidirectional causality of price change from Merta City market of Nagaur to Bhagat Ki Kothi market of Jodhpur but not vice versa. Thus, a change in Merta City cumin price will have instantaneous prices change in Bhagat Ki Kothi market of Jodhpur but not the other way round. This can be attributed to the fact that Merta City is the main trading market of cumin in Rajasthan hence shocks from the market is transferred to almost all cumin markets in the state. Contract farming, co-operatives and establishment of direct sale or purchase centres has contributed significantly in increasing the spatial price transmission between cumin markets in the state. Also, inclusion of cumin on agricultural futures exchanges and commodity exchange can also be attributed to the efficiency of cumin markets with an added advantage of advance price discovery and effective forward linkages like warehousing and financing to decrease distress sales of cumin. Futures trading provide arbitrage opportunity to the traders. In addition, high demand of cumin by international markets from India has increased the competitiveness of cumin markets thereby increasing marketing efficiency.

Table 7. Vector Autoregressive (VAR) model for the non co-integrated markets Granger Causality Wald Tests

Markets Pairs	Prob>chi 2	Direction	Short run causality
Nagaur ← Ajmer	0.736 , 0.031*	Unidirectional	Short run
Ajmer → Pali	0.050*, 0.113	Unidirectional	Short run
Ajmer ↔ Jodhpur	0.070*, 0.091*	Bidirectional	Short run
Ajmer → Jalore	0.006*, 0.825	Unidirectional	Short run
Jodhpur ↔ Pali	0.000*, 0.000*	Bidirectional	Short run
Jodhpur ↔ Jalore	0.016*, 0.051 *	Bidirectional	Short run

The unrestricted vector autoregressive (VAR) model was run for market pairs that were not cointegrated. The results of the Wald tests show that cumin price series between Ajmer and Jodhpur; Jodhpur and Pali and Jodhpur and Jalore Granger causes each other in the short run whereas Ajmer Granger causes Nagaur, Pali and Jalore in less than one month though in the long run they drift apart. The results generally show medium to high integration between markets. Thus not all the markets are integrated in the long run or even in the short run. It pre supposes that cumin markets have marketing bottlenecks which needs to be addressed in the state.

3.1 Impulse responses

Impulse response function is a shock to both VAR and ECM models used in the analysis. Positive shocks are shocks that affect the market prices of the markets in the consumption markets positively (i.e. a decrease in the price of cumin in the high arrivals or production area market i.e. Merta City, Ajmer, Jalore and Jodhpur market price (Bannor, 2015).

The results from table 8 show impulse response when, an unexpected positive shock or one positive standard

Table 8. Impulse response of markets from unexpected shocks to average cumin wholesaler prices in different selected markets

Unexpected shock to Markets	Response from Markets	Remarks on Type of Response
	Pali	Permanent
Nagaur	Jodhpur	Permanent
	Jalore	Permanent
Pali	Nagaur	Permanent
	Jodhpur	Transitory
	Pali	Transitory
Ajmer	Nagaur	Transitory
	Jodhpur	Transitory
	Jalore	Transitory
	Nagaur	Permanent
	Ajmer	Permanent
Jodhpur	Jalore	Transitory
	Pali	Transitory
	Nagaur	Permanent
Jalore	Ajmer	Transitory
	Jodhpur	Transitory

Source: Authors own computation

deviation is given to market prices of the selected markets. In other words, if there is unexpected decrease in price of one market, what will be the effect of the price of other pair market within a period of 12 months or one year as selected by the researchers? The results shows that orthogonalized shock or unexpected shocks to Nagaur market will result in permanent effect on the prices of other selected markets within one year. This is not surprisingly considering the high level of trading and production of cumin in Nagaur. In the same way, unexpected shock to market prices of Pali will result in permanent price effect on Nagaur cumin prices but temporary on prices in Jodhpur. On the other hand unexpected shock to prices of Ajmer will results in transitory or temporary price effect on prices in Pali, Nagaur, Jodhpur and Jalore markets. Generally, the results suggests that, when forecasting of prices of cumin, one should take into consideration the prices changes in Nagaur as it affects prices of all other markets positively.

4. Conclusions And Recommendations

Generally, cumin markets in the state are efficient with few markets not integrated or efficient both in the long run and short run however price forecasting should be made more available to farmers and other actors so as to increase the speed of adjustment of the integration between markets. The results have revealed how expected price changes in Merta City market of Nagaur do affect all other cumin market prices in the state. In the context of policy implications, Government should continue to invest in domestic cumin production, warehousing and other infrastructure to be able to increase and sustain the efficiency of the cumin markets in Rajasthan and its marketing channels. It is suggested that also, price forecasting of cumin prices should consider Merta City market prices during forecasting. Further study should be conducted to analyse the integration between cumin markets in Rajasthan, Gujarat and the world or international markets.

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