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Research Paper

Spatial linkages of green chili prices between a dedicated economic centre and other regional markets in Sri Lanka

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Abstract: This study assesses the green chili markets in Sri Lanka from 2012 to 2016 by examining the degree of market integration in the country. The analysis was carried out in the first differenced form, which conformed to the Augmented Dickey-Fuller tests of stationary. The pairwise comparison between Dambulla Dedicated Economic Centre

(DDEC) and 25 other regional markets in Sri Lanka was carried out. All market pairs co-integrated with the price at DDEC in the long run according to the results of Johansen Co-integration test. Therefore, the DDEC has clearly played an important role in price discovery in the long run. Error correction terms indicated that the adjustment process from short-term disequilibrium in prices to long run price equilibrium is slow providing evidence of weak short run co-integration in green chili markets in Sri Lanka. Results revealed only six regional markets out of 25 had serial correlation in the short run. Negative coefficients of prices in the short term indicated that some unknown factors are playing predominant role in spatial price transmission such as sluggishness in market convergence and inappropriate involvement of middleman in the market chain. Farm gate to the collecting centre and collecting centre to the regional markets were identified as the main two points in the market channel where high price influence has occurred. A systematic government inspection and a strong market information system could prevent such short term price disequilibrium in the regional chili markets in Sri Lanka to a greater extent.

Keywords: Green chili markets, Johansen co-integration, short-run disequilibrium, vector error correlation model (VECM)



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Introduction

Market integration is a good proxy for measuring efficiency in a marketing system. Spatial integration is concerned with the integration of spatially distinct markets (Venujayakanth *et. al.*, 2017). If price changes in one market are fully reflected in an alternative market, then these markets are said to be spatially integrated. The

concept of market integration is best described as the tradability between markets. Tradability signals the transfer of excess demand from one market to another captured as actual or potential trade flows. Positive trade flows are sufficient to demonstrate spatial market integration under the tradability standard, though prices may not be

equilibrated across markets (Barrett, 2007). Markets that are not integrated may convey inaccurate price information that might distort producer marketing decisions and contribute to inefficient product movements. Therefore, spatial price behaviour in regional markets for essential commodities is an important indicator of overall market performance. Further, special price relationships elicit the effectiveness of arbitrage and the efficiency of pricing (Sexton *et al.*, 1991). Where integration is efficient, farmers specialize in production activities and consumers pay lower prices for goods and society is better able to reap benefits (Vollrath, 2003).

Market integration of agricultural products in developing countries plays a pivotal attention due to its potential application to policy making. Further, agricultural products are perishable in nature and are supplied to market within a short time period after harvesting. More importantly, based on special price behaviours, governments could be able to implement suitable strategies in order to avoid market exploitation (Lohano and Mari, 2005). There are several studies that have dealt with the measurement of market co-integration, especially in food markets in many

Methodology

The degree of market intelligence was studied using data collected from the Dambulla Dedicated Economic Centre (DDEC) and 25 other regional markets (Table 1). The nominal prices of green chili were converted into real prices using the Colombo Consumer Price Index (CPI, Base: 2006/2007=100; DCS, 2008). The presence of unit root (non-stationary) in the underlying series is tested by performing using Augmented Dickey Fuller (ADF) test (Said and Dickey, 1984) and all the series were transformed into natural log-form to eliminate variations in movement due to level differences and to avoid spurious relationships. This test performs the regression as shown in Equation 1;

$$\Delta Y_t = \alpha + \delta T + \beta_1 Y_{t-1} + \sum_{i=1}^p \beta_i \Delta Y_{t-i} + \varepsilon_t \quad [\text{Eq. 1}]$$

where, $\Delta Y_t = Y_t - Y_{t-1}$, $\Delta Y_{t-1} = Y_{t-1} - Y_{t-2}$, and $\Delta Y_{t-2} = Y_{t-2} - Y_{t-3}$, etc., ε_t = pure white noise term, α = the

constant-term, T = the time trend effect, and p = the optimal lag value which is selected on the basis of Schwartz Information Criterion (SIC). The null hypothesis was that β_1 , the coefficient of Y_{t-1} , is zero. The Johansen co-integration test (Johansen and Juselius, 1990) was performed to verify the long-term relationships among market pairs. Co-integration tests provide evidence of how closely prices at different markets are linked. However, co-integration is absolute but present to a degree (Goodwin and Schroeder, 1991). The regression model (Equation 2) was used to study the long-run equilibrium to analyze the presence of short-run disequilibrium among the market pairs;

countries (Baulch, 1997; Engle and Granger 1987; Johansen, 1988; Johansen and Juselius, 1990). Most of the studies have focused on the major food grains such as rice, but no study has yet been focused particularly on widely spread field crops such as green chili (*Capsicum annuum* L), one of the most important field crops is grown in the dry zone in Sri Lanka.

The total annual requirement of green chili in Sri Lanka is 30,000 Mt and the average annual production is 9,237 Mt, which is insufficient to fulfil the demand in local market. As a result, price of green chili fluctuates heavily throughout the year. About 70% of the green chilies produced in Sri Lanka are collected and distributed by the Dambulla Dedicated Economic Centre (DDEC) and the island-wide price is determined by the DDEC (Ariyadasa, 2015). Thus, the main objective of this study was to examine the degree of market integration between DDEC and 25 other regional markets in Sri Lanka. Furthermore, the study identified the market locations where short run price disequilibrium occurs and possible rationale for such price disequilibrium and its effects are elaborated.

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$$\Delta P_t = \mu + \sum_{i=1}^{k-1} \tau_i \Delta P_{t-i} + \pi P_{t-k} + \beta_t + \varepsilon_t \quad [\text{Eq. 2}]$$

where, $\tau_i = -(A_{i+1} + \dots + A_k)$ $i = 1 \dots k - 1$, $\pi = (I - A_1 - \dots - A_k)$; μ = constant; $\varepsilon_t \sim \text{IID}(0, \Omega)$; Ω = covariance

matrix; Δ = prices differenced in order to achieve stationarity; π Pt-k = long run relationship. By full rank factorization the co-integration matrix 'π' can be decomposed into $\alpha\beta'$ whereby, both α and β are $n \times r$ matrices; r represents the number of co-

integration relationship with $0 < r < n$ and β represents co-integration vectors and α refers to the short run adjustment of the disequilibrium between market pairs.

Table 1. The market sites selected for the study

Market	Climatic Zone	Latitude	Longitude
Dambulla	Dry	7.866005° N	80.651767° E
Meegoda	Wet	6.821601° N	80.04753° E
Kandy	Wet	7.290572° N	80.633726° E
Jaffna	Dry	9.667333° N	80.009925° E
Nuwara Eliya	Wet	6.971721° N	80.766865° E
Badulla	Intermediate	6.980745° N	81.0602° E
Dehiaththakandiya	Dry	7.67128° N	81.046484° E
Divulapitiya	Wet	7.230314° N	80.016474° E
Embilipitiya	Wet	6.316232° N	80.843315° E
Galle	Wet	6.053519° N	80.220977° E
Kaluthara	Wet	6.585395° N	79.96074° E
Keppetipola	Intermediate	6.894721° N	80.86995° E
Mathara	Wet	5.95492° N	80.554956° E
Mannar	Dry	8.980974° N	79.904415° E
Hambanthota	Dry	6.142883° N	81.121231° E
Kilinochchi	Dry	9.380289° N	80.377° E
Kurunagala	Intermediate	7.472981° N	80.354729° E
Moneragala	Dry	6.756323° N	81.251883° E
Mulathivu	Dry	9.199583° N	80.58828° E
Nikaweratiya	Intermediate	7.746386° N	80.131693° E
Polonnaruwa	Dry	7.940338° N	81.018798° E
Anuradhapura	Dry	8.311352° N	80.403651° E
Puttalam	Dry	8.040791° N	79.839386° E
Thambuththegama	Dry	8.15163° N	80.291482° E
Thissamaharamaya	Dry	6.279154° N	81.287669° E
Ampara	Dry	7.231759° N	81.647344° E

* Dambulla Dedicated Economic Centre

Eigen values as rank (Π) refers to the number of co-integration relations. If the rank (Π) is less than n then there is an existence of co-integration relation. But in that case, the $\det(\Pi) = 0$. Thereby, the Eigen values are useful for solving this problem as $\det(\Pi) = \lambda_1 \lambda_2 \dots \lambda_n$. Eigen value of the Johansen test was computed by ordering the Eigen value by size $\lambda_1 > \lambda_2 > \dots > \lambda_n$.

The test of maximum Eigen value is a likelihood ratio test (Equation 3).

$$LR_{(r_0, r+1)} = T \ln(1 - \lambda_{r_0+1}) \quad [\text{Eq. 3}]$$

Trace test where the trace of matrix A is $\sum \lambda_i$ (sum of diagonal element of a matrix) since in the statistic $\sum \ln(1 - \lambda_i)$, was done and the $(1 - \lambda_i)$ occupies the diagonal position. The sum of these terms leads to the term trace statistic (Equation 4).

$$LR_{r_0, n} = -T \sum_{i=r_0+1}^n \ln(1 - \lambda_i) \quad [\text{Eq. 4}]$$

Although, markets may be integrated in long-run, there may be disequilibrium in the short run. To verify this, an Error Correction Model (ECM) was employed. The ECM was applied to investigate the short-run causality between the variables further and to establish the speed of adjustment of the

short-run disequilibrium to the long-run equilibrium.

The error correction model used in the study is same as given in Equation 2. The vector ' α ' in the equation represents the speed of adjustment towards long-run equilibrium. Data on weekly retail price (LKR/Kg) of green chili were collected

Results and Discussion

The null hypothesis could not be rejected for all price series as the absolute values of the ADF statistics are well below the 5% critical values of the test statistics and hence the price series are non-stationary (Figure 1). Thus, the analysis was carried out in first differenced form, which conformed to the ADF tests of stationary.

The results of the 25 pairwise comparisons of prices between the DDEC and the other regional market using bivariate co-integration tests are presented in Table 1. The λ -trace statistics showed that all market pairs are co-integrated, while both trace statistic values and maximum Eigen values are greater than 5% critical values ($P < 0.05$). The Johansen Co-integration test showed that the regional green chili markets are highly integrated with the prices at DDEC in the long run.

Even though the markets are integrated in the long-run, there may be disequilibrium in the shorter-run (Sidhu *et al.*, 2010). Positioned on error correction terms, the adjustment of that disequilibrium to access the long-run equilibrium path was predicted in the study. There was one co-integration relation existing in the pairwise comparisons and only one co-integration equation (rank) was included to the estimation. Accordingly, β was exactly identified and findings of both coefficients and P values are presented in Table 2. The results revealed that only six markets (Meegoda, Kandy, Jaffna, Nuwara Eliya, Badulla and Kaluthara) implied acceptance of the alternative hypothesis ($P < 0.05$) of serial correlation of residuals while that of 19 markets failed to reject the null hypothesis of no serial correlation of residuals ($P > 0.05$). A robust reason for not having a serial correlation would be that these 19 regional markets act as an oligopolistic

from 2012 to 2016 from the database available at the Hector Kobbekaduwa Agrarian Research and Training Institute (HARTI), Sri Lanka, to carry out the study. The long run relationship tested by using Engle Granger Bivariate Co-Integration Tests and short run relationships tested by using Vector Error Correlation Model (VECM) in STATA 14.

interdependency where firms compete only within a limited service area. Therefore, the short-run price disequilibrium is an inevitable observation especially for cash crops such as green chili in Sri Lanka. However, transportation within the limited area leads to inter-firm competition.

This situation may result in market linkages that follow non-competitive base-point pricing, which is maintained through an organized oligopoly arrangement (Faminow and Benson, 1990). Under the base-point, the pricing firms establish a base price at a central location and the delivered price to any location is the base price + transportation cost. Therefore, in the case of green chili, the within regional markets price is spatially integrated in the short run. However, between many regional markets and DDEC, the price was not spatially integrated in the short run.

The coefficient of the error correction terms (ECTs) turned out to be negative in many cases (Table 2). Hence, out of six markets, which had the short-run price equilibrium, four were directly affected by the negative price transmission. Furthermore, price at DDEC was directly negatively transmitted to 16 regional markets out of the 25 markets. These negative coefficients infer that, in addition to spatial price differences, some unknown factors are playing a predominant role in the spatial price transmission. Inappropriate involvement of middlemen in the green chili market chain has highly influenced the price fluctuations among the regional markets. They mainly get involved at two main points in the market channel, which are between the farm-gate to collecting centre and collecting centre to regional markets.

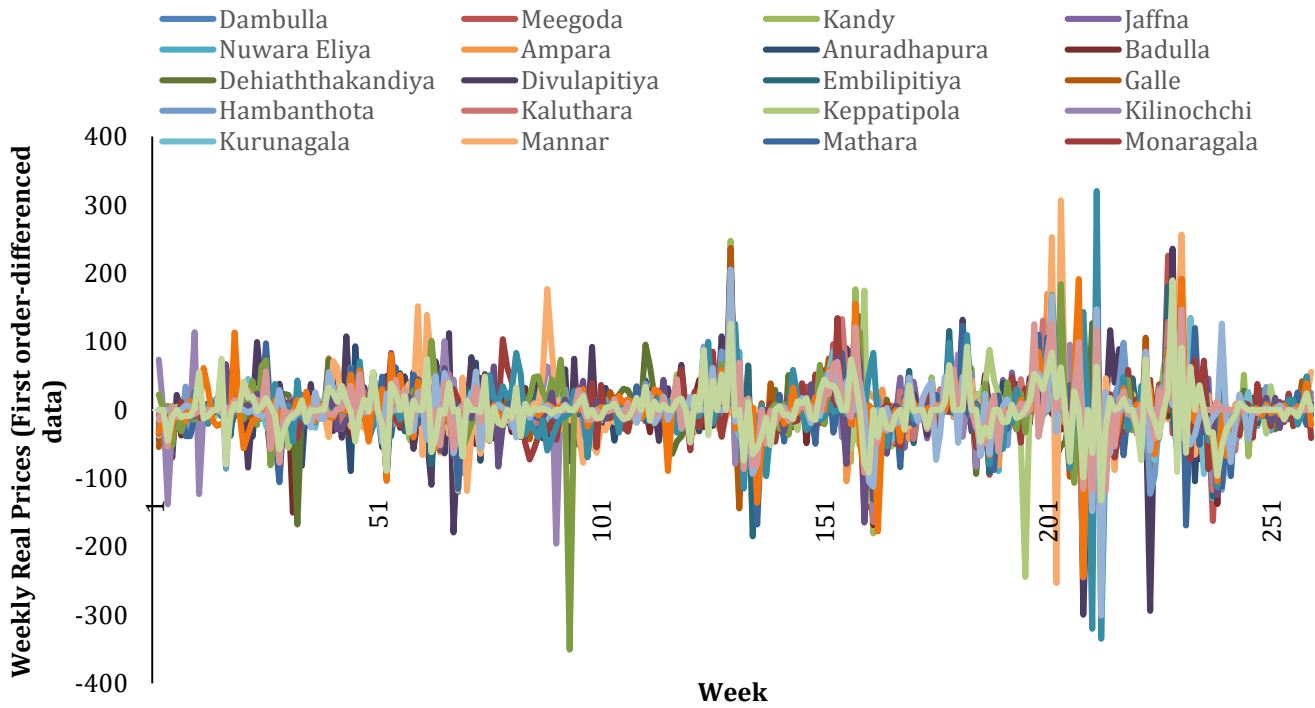
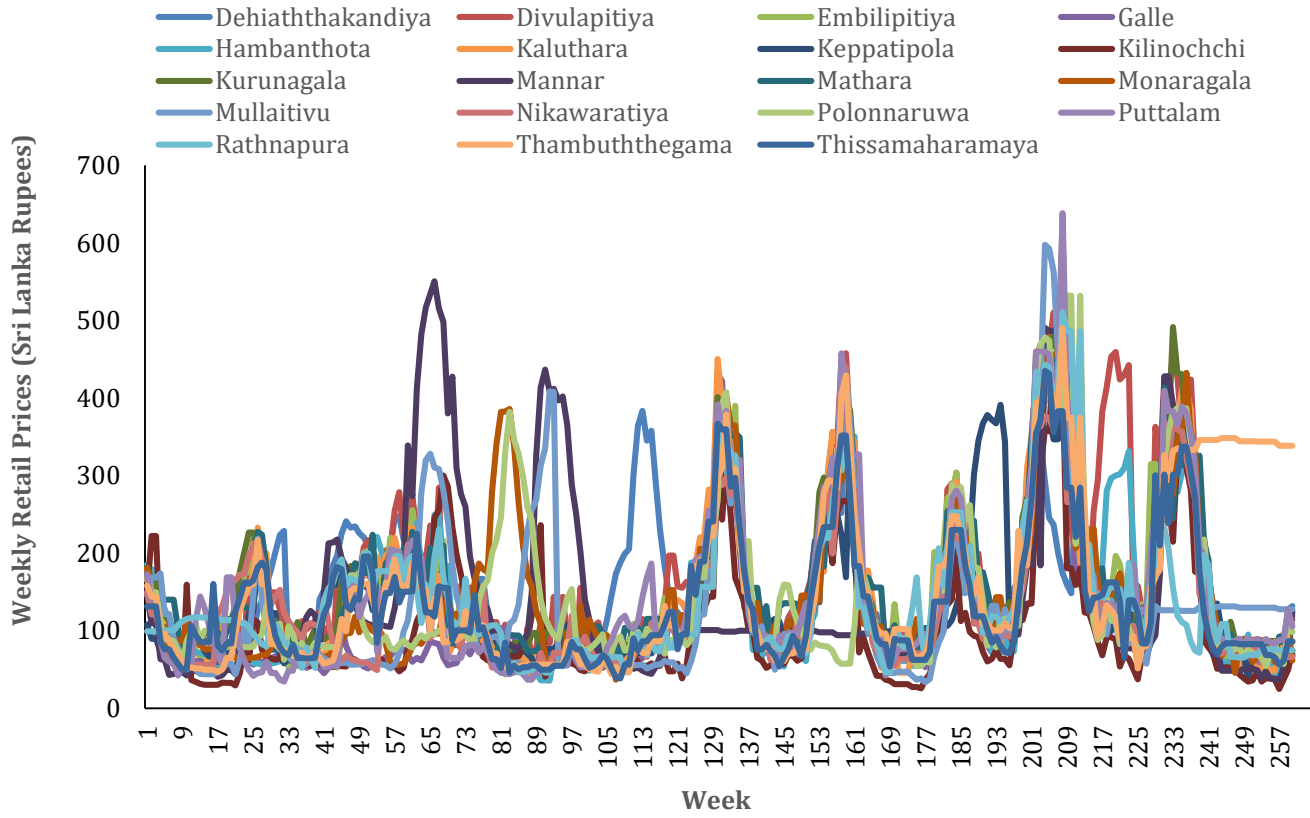


Figure 1. Weekly retail prices (a) and real prices (b) of chilli (note: real prices are given as first order-differenced data)

Table 1. Results of the pairwise comparisons between the prices at Dambulla Dedicated Economic Centre (DDEC) and the other regional markets using Johansen Co-integration test

Market pair	Trace statistic	Max. Eigen value	5% Critical value	Market pair	Trace statistic	Max. Eigen value	5% Critical value
Meegoda	11.34	11.34	3.76	Hambanthota	17.55	17.55	3.76
Kandy	11.48	11.48	3.76	Kilinochchi	15.19	15.19	3.76
Jaffna	19.74	19.74	3.76	Kurunegala	19.32	19.32	3.76
Nuwara Eliya	11.29	11.29	3.76	Moneragala	17.30	17.30	3.76
Badulla	19.10	19.10	3.76	Mulathivu	15.64	15.64	3.76
Dehiaththakandiya	14.26	14.26	3.76	Nikaweratiya	15.73	15.73	3.76
Divulapitiya	15.47	15.47	3.76	Polonnaruwa	15.96	15.96	3.76
Embilipitiya	17.87	17.87	3.76	Anuradhapura	10.17	10.17	3.76
Galle	17.13	17.13	3.76	Puttalam	16.12	16.12	3.76
Kaluthara	19.02	19.02	3.76	Thambuththegama	17.50	17.50	3.76
Keppatipola	14.89	14.89	3.76	Thissamaharamaya	16.76	16.76	3.76
Mathara	15.27	15.27	3.76	Ampara	9.76	9.76	3.76
Mannar	15.32	15.32	3.76				

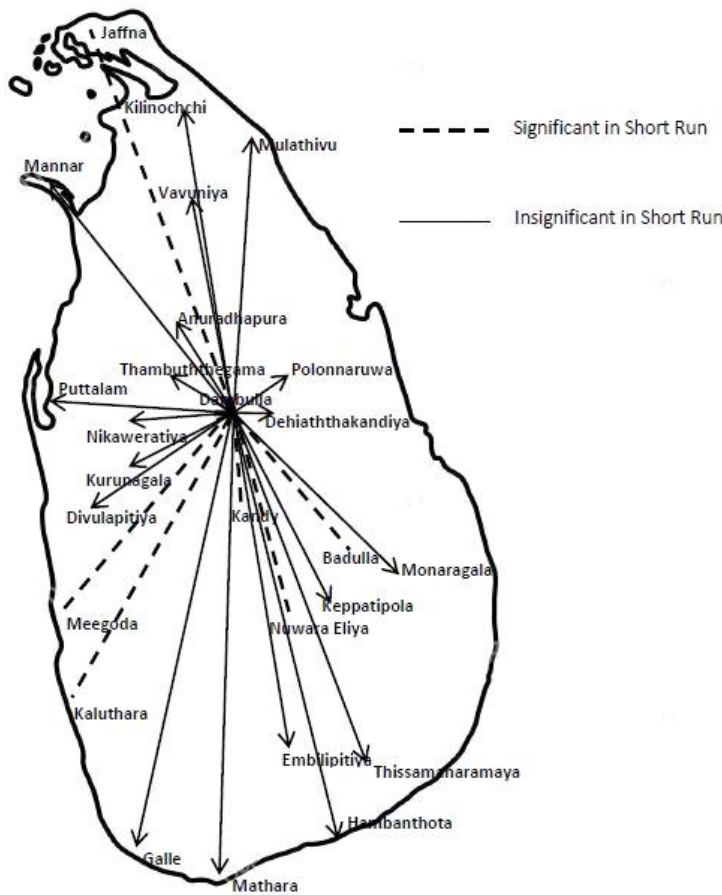
Table 2. Results of the Vector Error Correlation Model (VECM)

Regional Markets (Dependent variable)	DDEC* (Independent Variable)		Regional Markets (Dependent variable)	DDEC (Independent Variable)	
	Coef.	P Value		Coef.	P Value
Meegoda	-0.210	0.000	Hambanthota	-0.001	0.769
Kandy	-0.175	0.000	Kilinochchi	-0.006	0.408
Jaffna	0.025	0.019	Kurunegala	-0.002	0.682
Nuwara Eliya	-0.177	0.000	Moneragala	0.002	0.710
Badulla	0.016	0.049	Mulathivu	-0.005	0.457
Dehiaththakandiya	0.005	0.494	Nikaweratiya	0.004	0.501
Divulapitiya	-0.001	0.801	Polonnaruwa	0.001	0.870
Embilipitiya	-0.000	0.886	Anuradhapura	-0.000	0.982
Galle	-0.002	0.696	Puttalam	-0.001	0.794
Kaluthara	-0.180	0.000	Thambuththegama	0.002	0.629
Keppetipola	0.001	0.877	Thissamaharamaya	-0.003	0.680
Mathara	0.002	0.726	Ampara	-0.005	0.503
Mannar	-0.003	0.510			

* Dambulla Dedicated Economic Centre

Figure 2 illustrates the short run price integration of all 25 regional markets with the DDEC. Interestingly, the regional markets such as Kurunagala (58.5 km), Thambuththegama (59.1 km), Anuradhapura (63.7 km) and Polonnaruwa (67.9 km), which had the lowest distance to the DDEC showcased price disequilibrium in the short run. However, markets such as Jaffna (243.3 km)

and Kaluthara (186.7 km), which had comparatively higher distances to the DDEC showcased price integration in the short run. An irregular pattern of spatial integration was observed for green chili in Sri Lanka and hence, the government incorporative marketing chain systems should be implemented within these markets.



Regional market	Distance from DDEC (km)
Meegoda	151.1
Kandy	73.5
Jaffna	243.3
Nuwara Eliya	148.4
Badulla	147.7
Dehiaththakandiya	96.2
Divulapitiya	110.2
Embilipitiya	247.3
Galle	255.4
Kaluthara	186.7
Keppatipola	184.3
Mathara	285.0
Mannar	165.7
Hambanthota	277.3
Kilinochchi	184.3
Kurunegala	58.5
Moneragala	168.0
Mulathivu	180.2
Nikaweratiya	95.0
Polonnaruwa	67.9
Anuradhapura	63.7
Puttalam	121.8
Thambiththegama	59.1
Thissamaharamaya	245.0
Ampara	194.5

* Dambulla Dedicated Economic Centre

Figure 1. Short run price integration and distance in between Dambulla Dedicated Economic Centre and regional green chili markets in Sri Lanka [——— significant ($P < 0.05$) in the short-run; - - - - - non-significant ($P > 0.05$) in the short-run]

In any given market around the globe, the most important and essential resource is information. Without a proper information system markets do not function well. Therefore, establishment of a strong market information system within the agricultural markets is a timely and an important activity. This would obviously increase the market efficiency. According to the present study, the highest price manipulation occurred between the farm-gate to the collecting centres. Limited market information would lead to a poor bargaining power of farmers and this ultimately ends with a negative price transmission. Ineffective and inaccurate information results in a market price disequilibrium in the short-run for green chili in Sri Lanka. Data related to quantities of chili as well as other agricultural commodities that are delivered

on a daily basis or even in a particular season to separate markets are currently not available. This has created an incorrect price determination process throughout all the markets studied. Further, this results in free price-setting situation where middlemen acquire higher margins than the farmer. Hence, the presence of a systematic government inspection and a strong market information system could prevent such short-term price disequilibrium in the regional chili markets in Sri Lanka to a greater extent. If the government of Sri Lanka could establish a mechanism to obtain the quantities that are delivered to each market separately, this would lead to a better pricing mechanism, thus preventing unpredictable price fluctuations.

Conclusion

The findings disclosed that though the green chili markets in Sri Lanka are geographically separated, all of them displayed a common price movement and effective price signals of integration in the long-run. Some of the markets had short-run disequilibrium in prices. Some unknown factors may play a predominant role in the spatial price transmission such as sluggishness in market

convergence and inappropriate involvement of middlemen in the market chain. Regular government inspection will address this issue to a great extent. Developments in the transportation system, market infrastructure and rationalizing institutional constraints would further help in improving green chili markets in Sri Lanka.

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