The Spatial Integration of Vegetable Markets in Nepal

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ABSTRACT

This paper analyzes the spatial integration of vegetable markets in Nepal using weekly wholesale price and retail price data for three years. The maximum likelihood method of cointegration developed by Johansen (1988) was used in the study, which specifically examines if inter-regional vegetable markets are integrated and linked together into a single economic market. The dynamics of short-run price responses were examined using the vector error correction model (VECM). The results indicated that the higher the perishability, the lesser the integration was among wholesale markets and among retail markets of different vegetables. By examining the short-run price adjustment, it was found that almost all vegetable markets reacted on the long-run cointegrating equations while the speed of price adjustment in the short-run was almost absent. Moreover, it was found that the longer the distance between markets, the weaker the integration was. To increase the efficiency of vegetable markets in Nepal, there is a need to focus on building an improved market information system. This system should be able to disseminate timely market information about price, demand, and supply of products to enable producers, traders, and consumers to make proper production and marketing decisions.

INTRODUCTION

Nepal, one of the developing countries in the South Asian region, relies heavily on agriculture for self-sufficiency in national food requirements, adequate production of raw materials, local agro-based industries, and the generation of substantial surplus. The preliminary contribution of the agriculture and forest sectors to the gross domestic product (GDP) was estimated to be 33.03 percent in fiscal year 2009-2010, with an annual growth rate of 1.05 percent. Richly endowed with natural resources, Nepal has great potential to further develop its agricultural sector. According to agro-ecological zones, *terai* (plain) and hill areas are the main vegetable-producing areas.[1] Among agricultural commodities, horticultural

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1 The country is divided into three agro-ecological regions, namely, mountain (35%), hill (42%), and plain (23%). The hill and plain regions contribute about 56 percent and 39 percent of total national vegetable production, respectively.

crops play a significant role in the country's agricultural development and economic growth. The horticultural sector contributes about 13.76 percent to agricultural GDP. Horticultural crops occupy 3.07 percent of the total cultivated area in Nepal. Among them, vegetable cultivation is one of the important short seasonal and major crop enterprises of the Nepalese agricultural system. It contributed as high as 46 percent to horticultural GDP. Meanwhile, vegetable crops occupied 68.47 percent of the area under cultivation, contributing 80.05 percent of the total national horticultural production. Vegetables are supplied seasonally to local markets and some are available throughout the year. Nepal can produce certain vegetables year round because of its varied climate and geographical conditions. However, due to long-distance transportation costs, the price changes seasonally.

The nature of markets and their role in price determination are central to economies. Spatial price behavior in regional markets is an important indicator of overall market performance. Typically, agricultural products are bulky and/or perishable and the area of production and consumption are far apart; hence, transportation is costly. To measure demand and supply, price discovery, and structure of competition, geographical boundaries of a market are important.

The geographical integration of markets determines the extent to which weather risk is shared over space by smoothing idiosyncratic price variations. Integrated markets have limited price differences in time, form, and space when it comes to marketing costs. Markets that are not integrated may convey inaccurate price signals that might distort producers' marketing decisions and contribute to inefficient product movements (Tomek and Robinson 1990). If price movements of a commodity in one market are completely irrelevant to forecast price movements of the same commodity in other markets, the markets are characterized as segmented. The success of trade opening up among regions will depend on the strength of price signal transmission among the markets in various regions of a country. The spread of price information is an important factor that affects market integration, which can also be influenced by transportation, seasonal factors, intervention of governments, characteristics of different products, and presence of self-sufficient production. The growing trend toward liberalization of food markets and recent advances in time-series econometrics, especially those related to cointegration and error correction methods, have led to an explosion in the literature on testing food market integration in many countries. Some of these studies include Asche et al. (1999), Ismet et al. (1998), Baulch (1997), Goletti et al. (1995), Dercon (1995), Alexander and Wyeth (1994), Dahlgram and Blank (1992), Godwin and Schroeder (1991), Faminow and Benson (1990), and Ravallion (1986).

The most common methodology used in the past for testing market integration involved the estimation of bivariate correlation coefficient between price changes in different markets (Cummings 1967 and Lele 1967, 1971). This method was strongly criticized by Blyn (1973), Harriss (1979), Heytens (1986), and Ravallion (1986, 1987). The studies based on bivariate correlation were found to have methodological flaws. The most significant contribution to market integration methods came from Ravallion (1986) who proposed a dynamic model of spatial price differentials. However, this method also involves serious problems that result in inefficient estimators, which are used for testing alternative hypotheses of market integration and segmentation. Meanwhile, Palaskas and Harriss-White's (1993) study involves serious methodological

defects inherent in the Engle and Granger (1987) method of cointegration. Moreover, the method does not provide any procedure of testing multiple cointegrating vectors when there are three or more variables. Naturally, for conducting the test of market integration properly using the Engle-Granger cointegration method, it is necessary to identify the central (exogenous) and the peripheral (endogenous) markets. Palaskas and Harriss-White (1993) apparently resolved this problem by identifying the central and the peripheral markets on the basis of population data, volumes, and direction of flows of commodities and nodes of transport networks. However, this is not the safest way to eliminate the possibility of an endogeneity problem because prices are often determined simultaneously. A better way to resolve the problem is to use the multivariate cointegration method developed by Johansen (1988). This method treats all the variables as explicitly endogenous and takes care of the endogeneity problem by providing an estimation procedure that does not require an arbitrary choice of a variable for normalization. It also allows tests for multiple cointegrating vectors.

Very little has been done in the past in terms of evaluating food market integration in Nepal. The present study analyzes the spatial integration of vegetable markets in the country by using recently developed cointegration techniques.

METHODOLOGY

The maximum likelihood (ML) method of cointegration developed by Johansen (1988) was used in this study, which specifically examines if inter-regional vegetable markets are integrated and linked together into a single economic market. The data set employed in the cointegration exercise consisted of separate weekly wholesale prices and retail prices of major vegetables from April 2007 to March 2010. The data related to the prices of major vegetables in different markets of hill and plain regions were compiled from various issues of the Fruit and Vegetable Price Bulletin published by the Federation of Nepal Chambers of Commerce and Industry. The choice of the market centers from each region was constrained by the availability of consistent data from the period under consideration. On that basis, the following market centers were chosen: Dharan (DHA), Kalimati (KAL), Pokhara (POK), and Palpa (PAL) from the hill region and Birtamod (BIR), Narayangadh (NAR), Butwal (BUT), Nepalgunj (NEP), Kanchanpur (KAN), and Surkhet (SUR) from the plain region.[2] Major vegetables like local tomato, red potato, dry onion, cabbage, and cauliflower were selected for the study.[3]

ANALYTICAL FRAMEWORK

Two markets are considered spatially integrated if, in the presence of trade between them, the price in the importing market $\left(P_t^i\right)$ is equal to the price in the exporting market $\left(P_t^e\right)$ including transport and other transfer costs involved in moving goods between them $\left(T_t^{ie}\right)$. This happens because of spatial arbitrage condition given by $P_t^i = P_t^e + T_t^{ie}$. However, market integration does not necessarily imply that markets are competitive. Generally, the approaches that are used for testing market

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2 Data of weekly wholesale prices and retail prices are available for only 10 out of 12 fruit and vegetable wholesale markets of Nepal.
3 Among the 12 fruit and vegetable wholesale markets, Kalimati is the country's largest market situated in Kathmandu, the capital city of Nepal. The five vegetables selected had the highest share of arrivals in the Kalimati market.

integration may be classified into two broad categories. First, Law of One Price (LOP), tests for perfect co-movement of prices and assumes that if markets are integrated, price changes in the exporting market will be transmitted to the importing markets on a one-for-one basis. LOP requires that trade flows between two markets must occur in every period and prices in one market are determined exogenously. However, these are highly restrictive assumptions that are rarely satisfied in reality.

To avoid some of these problems, a second approach, (i.e., cointegration), is used to test for a more general notion of spatial market integration. A cointegration test can be used even when the co-movement of prices is less than perfect, prices are determined simultaneously, and there are seasonal variations in transfer costs. LOP holds if there are *n*-1 cointegrating vectors and thus all *n* number of prices contain a common stochastic trend. It is for these reasons, and because most prices tend to be non-stationary, that cointegration in terms of a long-run linear relationship between prices occurs. This study employed the ML method of cointegration. This method allows the testing of multiple cointegrating vectors in a multivariate framework. Since this test is carried out in a reduced form vector autoregressive (VAR) model, it does not involve the endogeneity problem. As such, the test results remain invariant to the choice of the variable selected for normalization in the regression.

A cointegration test does not require the examination of the univariate time-series properties of the data. It confirms that all price series are non-stationary and integrated in the same order. This is performed using the Augmented Dickey-Fuller (ADF) test developed by Dickey and Fuller (1979, 1981). The test is based on the statistics obtained from applying the ordinary least squares (OLS) method to the following regression equation:

$$\Delta P_t = \alpha + \theta P_{t-1} + \sum_{i=1}^{k} \gamma_i \Delta P_{t-1} + \varepsilon_t \quad (1)$$

Where k = number of lagged difference terms required so that the error term ε_t is serially independent.

To determine whether P_t is non-stationary, the tau-statistic (τ), $\tau = \frac{\theta - 1}{s.e.(\theta)}$ is used to test the unit-root null hypothesis $H_0: \theta = 0$. Since τ does not have the usual properties of the student-*t* distribution, there is a need to use critical values tabulated by Fuller (1976) for testing the level of significance. The lagged first difference terms are included in the equations to take care of possible correlation in the residuals. If the unit-root null is rejected for the first-difference of the series but cannot be rejected for the level, then the series contains one unit root and is integrated of order one, I(1). The lag length, at which the prices are mostly integrated, was defined by using VAR on the differenced series. In VAR analysis, Akaike Information Criterion (AIC) and Schwartz Criterion (SC) were used to select a suitable lag length. These are important method as inclusion of too many lagged terms will introduce the problem of multicollinerity and too few lags will lead to specification error. The lower the values of the AIC and SC statistics the better the model is.

Cointegration Test

Following Johansen (1990), the ML method of cointegration may be briefly outlined here. If P_t denotes an (n×1) vector of I(1) prices, then the k-th order VAR representation of P_t may be written as:

$$P_t = \sum_{i=1}^{k} \prod_i P_{t-1} + \varepsilon_t \ (t = 1,2,\dots,T) \ (2)$$

The procedure for testing cointegration is based on the error correction (ECM) representation of P_t given by:

$$\Delta P_t = \sum_{i=1}^{k-1} \Gamma \Delta P_{t-1} + \prod P_{t-k} + \varepsilon_t \quad (3)$$

Where,

$$\Gamma_i = -(I - \Pi_1 - \cdots\cdots, -\Pi_t); i$$
$$= 1,2, \cdots\cdots, k-1; \Pi$$
$$= -(I - \Pi_1 - \cdots\cdots, -\Pi_k)$$

Each of Π_l is n × n matrix of parameters; ε_t is an independently distributed n-dimensional vector of residuals with zero mean and variance matrix. Since P_{t-k} is I(1), but ΔP_t and ΔP_{t-i} variables are I(0), equation (2) will be balanced if ΠP_{t-k} is I(0). So, it is the matrix that conveys information about long-run relationship among the variables in P_t. The rank of Π, r, determines the number of cointegrating vectors, as it determines how many linear combinations of P_t is stationary. If r = n, the prices are stationary in levels. If $r = 0$, no linear combination of P_t is stationary. If 0< rank (Π) = r < n (Enders 1995), and there are $n \times r$ matrices α and β such that $\Pi = \alpha \grave{\beta}$, then it can be said that there are r cointegrating relations among the elements of P_t. The cointegrating vector β has the property that $\grave{\beta} P_t$ is stationary even though P_t itself is non-stationary. The matrix α measures the strength of the cointegrating vectors in the ECM, as it represents the speed of adjustment parameters.

Two likelihood ratio test statistics are proposed. The null hypothesis of at most r cointegrating vector against a general alternative hypothesis of more than r cointegrating vectors is tested by the trace statistic:

$$(\lambda-\text{trace}) = -T \sum_{i=r+1}^{n} \ln(1 - \hat{\gamma}_1)$$

The null hypothesis of exactly r cointegrating vectors against the alternative of $r+1$ is tested by the maximum Eigen value statistic:

$$(\lambda\gamma-\text{max}) = -T \ln(\hat{\lambda}_{r+1})$$

$\hat{\lambda}_i$'s are the estimated values of the characteristic roots (also called Eigen values) obtained from the estimated matrix; T is the number of usable observations. The number of cointegrating vectors indicated by the tests is an important indicator of the extent of co-movement of the prices. An increase in the number of cointegrating vectors implies an increase in the strength and stability of price linkages.

RESULTS AND DISCUSSION

The estimated test statistics from ADF tests for wholesale and retail prices in levels and first differences are reported in Table 1. It can be seen that the null hypothesis of non-stationarity cannot be rejected for both wholesale prices and retail prices in levels, but can be rejected for all the prices in first differences. Therefore, wholesale prices and retail prices were non-stationary in their levels but stationary in first differences. This implies that all wholesale and retail price series contained a single unit root and were integrated in order of one. As such, taking first differences as variables in the model eliminates the stochastic trend in the nominal series.

The cointegration tests were then conducted since the entire wholesale price series and retail price series were integrated in the same order. The integration of vegetables markets was evaluated by investigating the long-run relationship between the wholesale price series of the major vegetables in spatially separated locations in hill and plain regions. The same was done using the retail price series. The results of the multivariate cointegration tests for wholesale price series of major vegetables are reported in Table 2.

Table 1. Results of the ADF test for the order of integration

Markets	Wholesale Price		Retail Price	
	Level	First-difference	Level	First-difference
Tomato (local)				
Kalimati (KAL)	2.408 (2)	11.04 (2)*	1.573 (2)	11.07 (2)*
Pokhara (POK)	2.769 (2)	12.09 (2)*	2.206 (2)	9.89 (2)*
Butwal (BUT)	3.009 (2)	13.88 (2)*	1.818 (2)	10.12 (2)*
Kanchanpur (KAN)	2.468 (2)	12.60 (2)*	2.460 (2)	9.75 (2)*
Potato (red)				
Birtamod (BIR)	1.741 (2)	11.69 (2)*	1.780 (2)	13.39 (2)*
Dharan (DHA)	1.818 (2)	9.350 (2)*	1.385 (2)	10.23 (2)*
Kalimati (KAL)	1.949 (2)	7.128 (2)*	1.768 (2)	7.98 (2)*
Narayangadh (NAR)	1.396 (2)	10.35 (2)*	1.342 (2)	11.15 (2)*
Nepalgunj (NEP)	1.802 (2)	11.21 (2)*	1.674 (2)	10.91 (2)*
Pokhara (POK)	1.150 (2)	10.97 (2)*	1.294 (2)	9.44 (2)*
Kanchanpur (KAN)	2.356 (2)	4.27 (2)*	1.560 (2)	13.49 (2)*
Surkhet (SUR)	1.612 (2)	12.25 (2)*	1.696 (2)	12.48 (2)*
Butwal (BUT)	2.413 (2)	11.73 (2)*	2.297 (2)	12.04 (2)*
Onion (dry)				
Birtamod (BIR)	1.746 (2)	10.77 (2)*	1.756 (2)	10.85 (2)*
Dharan (DHA)	2.400 (2)	8.29 (2)*	1.897 (2)	9.55 (2)*
Kalimati (KAL)	1.624 (2)	9.98 (2)*	2.095 (2)	11.94 (2)*
Narayangadh (NAR)	2.218 (2)	10.38 (2)*	2.035 (2)	14.34 (2)*
Nepalgunj (NEP)	1.961 (2)	9.68 (2)*	0.900 (2)	10.15 (2)*
Pokhara (POK)	2.510 (2)	4.77 (2)*	2.170 (2)	11.75 (2)*
Kanchanpur (KAN)	1.372 (2)	7.91 (2)*	1.520 (2)	8.15 (2)*
Surkhet (SUR)	2.476 (2)	11.44 (2)*	2.367 (2)	12.21 (2)*
Butwal (BUT)	2.660 (2)	9.60 (2)*	2.676 (2)	10.81 (2)*
Palpa (PAL)	1.902 (2)	10.35 (2)*	1.778 (2)	9.57 (2)*
Cabbage				
Birtamod (BIR)	2.283 (2)	11.37 (2)*	2.026 (2)	11.12 (2)*
Dharan (DHA)	2.743 (2)	16.27 (2)*	2.710 (2)	14.96 (2)*
Kalimati (KAL)	2.413 (2)	11.60 (2)*	2.469 (2)	8.07 (2)*
Narayangadh (NAR)	2.041 (2)	13.05 (2)*	1.975 (2)	13.92 (2)*
Nepalgunj (NEP)	2.312 (2)	11.87 (2)*	2.481 (2)	12.75 (2)*
Pokhara (POK)	1.887 (2)	13.77 (2)*	1.528 (2)	14.60 (2)*
Kanchanpur (KAN)	2.042 (2)	11.86 (2)*	2.016 (2)	9.66 (2)*
Surkhet (SUR)	2.041 (2)	7.87 (2)*	1.953 (2)	7.55 (2)*
Butwal (BUT)	2.144 (2)	11.68 (2)*	2.216 (2)	11.65 (2)*
Palpa (PAL)	1.915 (2)	15.13 (2)*	1.952 (2)	18.86 (2)*

Note: *Significant at 1 percent level. The negative signs before the test statistics are omitted. Figures in parentheses are the optimal numbers of augmenting lags selected by Akaike Information Criterion (AIC) and Schwartz Criterion (SC). Number of observation (*n*) is 144 except for markets of onion (dry), which is 116.

Table 1. Results of the ADF test for the order of integration ... *(Continued)*

Markets	Wholesale Price		Retail Price	
	Level	First-difference	Level	First-difference
Cauliflower				
Birtamod (BIR)	2.372 (2)	10.21 (2)*	2.392 (2)	10.33 (2)*
Dharan (DHA)	2.873 (2)	12.60 (2)*	2.624 (2)	12.22 (2)*
Kalimati (KAL)	2.382 (2)	11.16 (2)*	2.768 (2)	8.72 (2)*
Narayangadh (NAR)	2.667 (2)	12.63 (2)*	2.566 (2)	11.48 (2)*
Nepalgunj (NEP)	2.028 (2)	12.09 (2)*	1.997 (2)	12.14 (2)*
Pokhara (POK)	2.069 (2)	10.81 (2)*	2.374 (2)	12.25 (2)*
Kanchanpur (KAN)	2.096 (2)	10.96 (2)*	2.067 (2)	11.21 (2)*
Surkhet (SUR)	2.550 (2)	11.01 (2)*	2.707 (2)	12.02 (2)*
Butwal (BUT)	2.538 (2)	12.48 (2)*	2.471 (2)	11.95 (2)*
Palpa (PAL)	2.824 (2)	13.33 (2)*	2.718 (2)	13.34 (2)*

Note: *Significant at 1 percent level. The negative signs before the test statistics are omitted. Figures in parentheses are the optimal numbers of augmenting lags selected by Akaike Information Criterion (AIC) and Schwartz Criterion (SC). Number of observation (*n*) is 144 except for markets of onion (dry), which is 116.

Table 2. Cointegration results for spatial integration of wholesale markets of major vegetables

Trace test			Maximum Eigen Value test		
Null Hypothesis	λ -trace	5% critical Value	Null Hypothesis	λ –max	5% critical Value
Tomato-Local					
r = 0	74.30**	47.80	r = 0	32.61**	27.58
r ≤ 1	41.69**	29.79	r = 1	24.26**	21.13
r ≤ 2	17.42**	15.49	r = 2	11.51	14.26
Potato-Red					
r = 0	301.03**	197.37	r = 0	69.78**	58.43
r ≤ 1	231.25**	159.52	r = 1	58.46**	52.36
r ≤ 2	172.78**	125.61	r = 2	51.96**	46.23
r ≤ 3	120.82**	95.75	r = 3	42.57**	40.07
r ≤ 4	78.24**	68.81	r = 4	37.26**	33.87
r ≤ 5	40.98	47.85	r = 5	16.29	27.58
Onion-Dry					
r = 0	359.04**	239.23	r = 0	100.48**	64.50
r ≤ 1	258.56**	197.37	r = 1	66.62**	58.43
r ≤ 2	191.93**	159.52	r = 2	52.66**	52.36
r ≤ 3	139.27**	125.61	r = 3	43.02	46.23
Cabbage					
r = 0	296.00**	239.23	r = 0	71.99**	64.50
r ≤ 1	224.00**	197.37	r = 1	56.83**	58.43
r ≤ 2	167.16**	159.52	r = 2	52.04	52.36
Cauliflower					
r = 0	295.83**	239.23	r = 0	60.78	64.50
r ≤ 1	235.04**	197.37	r = 1	49.03	58.43
r ≤ 2	186.01**	159.52	r = 2	47.56	52.36
r ≤ 3	138.45**	125.61	r = 3	36.10	46.23

Note: **denotes rejection of the hypothesis at 5 percent significance level

The main task was to examine the rank Π or the number of cointegrating vectors for wholesale price series of major vegetables. Using the cointegration test available in EViews, the rank of Π was determined. The λ–max test, also known as ML ratio test, was more powerful than the trace test. The λ–max test indicated the presence of l cointegrating vector for wholesale markets of local tomato at 5 percent level of significance. Further, the test defined the rank of Π= 4 for wholesale markets of red potato and 2 for wholesale markets of dry onion. The above empirical evidence suggests that the wholesale price series of all the markets of local tomato, red potato, and dry onion were cointegrated to a long-run equilibrium. The farmers transfer their produce from one market to the other according to the price changes. Meanwhile, arbitrage through trade ties their prices together. However, the cointegrating vector for cabbage and cauliflower wholesale markets was absent at 5 percent level of significance. Similarly, the results of the multivariate cointegration tests

for retail price series of major vegetables are presented in Table 3.

The λ–max test for retail markets of major vegetables indicates the presence of one cointegrating vector each for retail markets of dry onion and cabbage at 5 percent significance level. The above empirical evidence suggests that the retail price series of dry onion and cabbage markets were cointegrated to a long-run equilibrium. However, the cointegrating vector for local tomato, red potato, and cauliflower retail markets was absent at 5 percent level of significance.

For the long-run price cointegration in wholesale vegetable markets, the cointegrating equations that were normalized according to the rank are shown in Table 4. One cointegrating equation was obtained for local tomato by normalizing with respect to POK wholesale price; four cointegrating equations were obtained for red potato by normalizing with respect to BIR, DHA, KAL, and NAR wholesale prices; and two cointegrating equations were

Table 3. Cointegration results for spatial integration of retail markets of major vegetables

Null Hypothesis	Trace test		Null Hypothesis	Maximum Eigen Value test	
	λ -trace	5% Critical Value		λ –max	5% Critical Value
Tomato-Local					
r=0	72.61**	47.85	r = 0	39.36**	27.58
r≤1	33.24**	29.79	r = 1	20.00	21.13
Potato-Red					
r = 0	286.10**	197.37	r = 0	66.29**	58.433
r ≤ 1	219.81**	159.52	r = 1	52.34	52.362
r ≤ 2	167.46**	125.61	r = 2	45.41	46.231
r ≤ 3	119.05**	95.75	r = 3	39.44	40.077
r ≤ 4	76.49**	68.81	r = 4	31.44	33.876
r ≤ 5	45.05	47.85	r = 5	21.87	27.584
Onion-Dry					
r = 0	329.89**	239.23	r = 0	86.28**	64.50
r ≤ 1	243.60**	197.37	r = 1	65.64**	58.43
r ≤ 2	177.96**	159.52	r = 2	46.88	52.36
Cabbage					
r = 0	309.99**	239.23	r = 0	85.657**	64.504
r ≤ 1	224.34**	197.37	r = 1	69.406**	58.433
r ≤ 2	154.93	159.52	r = 2	50.975	52.362
Cauliflower					
r = 0	290.57**	239.23	r = 0	69.225**	64.504
r ≤ 1	221.34**	197.37	r = 1	55.132	58.433

Note: **denotes rejection of the hypothesis at 5 percent significance level

Table 4. Estimation of long-run wholesale price integration of major vegetables

Tomato-Local						
POK =	-1.73 KAL (-8.436)*	+1.50 BUT (3.703)*	-0.61 KAN (-2.543)*			CointEq (1)
Potato-Red						
BIR =	-1.16 NEP (-8.516)*	+0.61 POK (6.501)*	-0.22 KAN (-2.074)	+0.09 SUR (1.317)	-0.22 BUT (-2.890)*	CointEq (1)
DHA=	-5.95 NEP (8.205)*	-1.98 POK (-3.431)*	+0.76 KAN (1.518)	+1.70 SUR (2.140)	+4.01 UT(6.319)*	CointEq (2)
KAL =	+1.35 NEP (4.245)*	+1.10 POK (4.674)*	-0.17 KAN (-0.630)	-0.41 SUR (-1.447)	-1.79 BUT (-6.467)*	CointEq (3)
NAR=	+2.41 NEP (5.472)*	+1.00 POK (2.857)*	-1.35 KAN (-4.426)*	-1.47 SUR (-3.703)*	-2.73 BUT (-7.054)*	CointEq (4)
Onion-Dry						
BIR =	-0.47 DHA (5.141)*	-0.79 KAL (-6.545)*	-0.13 SUR (-2.109)	+0.48 POK (5.020)*	+0.40 PAL (5.025)*	
			-0.22 KAN (-2.229)	+0.01 NAR (3.333)*	-0.35 NEP (-4.395)*	CointEq (1)
BUT=	+0.50 DHA (2.273)*	-1.33 KAL (-4.547)*	-0.39 SUR (-2.529)*	+1.07 POK (4.600)*	+1.00 PAL (5.154)*	
			-0.27 KAN (-1.658)	-0.01 NAR (-4.473)*	-1.47 NEP (-7.477)*	CointEq (2)

Note: All the values in parentheses are *t*-values; *Significant at 1 percent level of significance and critical *t*-value= 2.32

obtained for dry onion by normalizing with respect to BIR and BUT wholesale prices. The results of long-run wholesale price integration using Johansen's ML test could explain why POK was integrated with all the wholesale markets to which it distributed the local tomato vegetable as the transit market. In the case of red potato, NAR was highly integrated with NEP, POK, KAN, SUR, and BUT markets. However, BIR, DHA, and KAL markets were only integrated with NEP, POK, and SUR markets, which showed that the longer distance made the integration weaker. This fact was also explained in the case of dry onion, wherein BIR and BUT

markets cannot be integrated with KAN and SUR markets. Further, the results indicated the lack of integration for cabbage and cauliflower wholesale markets.

Similarly, for the long-run price cointegration in retail vegetable markets, the cointegrating equations that were normalized according to the rank are shown in Table 5. The result of long-run retail price integration of the markets of major vegetables indicates that one cointegrating equation is obtained each for dry onion and cabbage by normalizing with respect to DHA retail prices. In the case of dry onion, DHA market was integrated significantly with

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Table 5. Estimation of long-run retail price integration of major vegetables

			Onion-Dry			
DHA =	+76.02 KAL (8.101)*	-4.92 PAL (-0.853)	-11.32 POK (-1.789)	+6.83 BIR (0.725)	-35.56 NAR (-4.530)*	CointEq (1)
		-7.55 BUT (1.194)	-23.91 NEP (3.569)*	+6.40 SUR (1.052)	-4.06 KAN (-0.704)	
			Cabbage			
DHA =	+0.54 KAL (7.55)*	+0.57 PAL (6.662)*	+0.07 POK (0.890)	-1.64 BIR (-11.605)*	-0.68 NAR (-8.922)*	CointEq (1)
		+0.04 BUT (0.396)	+0.16 NEP (1.824)	+0.02 SUR (0.367)	-0.21 KAN (2.233)	

Note: All the values in parenthesis are *t*-values; *Significant at 1 percent level of significance and critical *t*-value= 2.32

KAL, NAR, and NEP retail markets whereas it was segmented from distant retail markets like POK, BUT, SUR, and KAN. This implies that the longer the distance, the weaker the integration. The same situation was observed for the retail markets of cabbage in which DHA was integrated with KAL, PAL, BIR, and NAR. However, it was observed that there was no integration between the retail markets of vegetables like local tomato, red potato, and cauliflower in Nepal.

Testing for short-run integration can be incorporated in the Vector Error Correction Model (VECM) using the same price series, only when the long-run integration is observed. The short-run dynamics of wholesale prices of major vegetables are presented in Table 6. A principal feature of cointegrated variables is that their time paths are influenced by the extent of any deviation from long-run equilibrium (Walter Anders 1995). After all, if the system is to return to the long-run equilibrium, the movement of at least some of the variables must respond to the magnitude of the disequilibrium. The larger the coefficient of the cointegrating relation in the regression, the stronger the reaction of the markets in the short run. It is seen from the table that in the case of local tomato, KAL was the strongest follower of the cointegrating equation with a speed of adjustment of about 30 percent.

In the case of red potato, BUT was the strongest follower of cointegrating equation 1 with a speed of adjustment of 31 percent. KAL market was the strongest follower of cointegrating equation 2 and 3 while NAR market was the follower of cointegrating equation 4. In the case of dry onion, KAL and NAR markets were the strongest followers of cointegrating equation 1 and 2, respectively. In general, it can be said that KAL and NAR markets are special markets as they reacted to all the cointegrating equations for all three vegetables.

Similarly, the short-run dynamics of retail prices of major vegetables are presented in Table 7. It was observed that the cointegration equations (i.e., long-run relationship) existed for retail markets of dry onion and cabbage only. Hence, the short-run relationship can be seen for these vegetables. Table 6 reveals that DHA retail market was the strongest follower of change in retail prices of dry onion with a price adjustment speed of 73 percent, followed by KAL and PAL markets. In the case of cabbage, KAL market was the strongest follower of change in retail prices with an adjustment speed of 68 percent.

The cointegration results observed a strong long-run relationship of wholesale prices among all the markets of local tomato, red potato, and dry onion vegetables. However, the results of

Table 6. Estimation of short-run dynamics of wholesale prices of major vegetables in Nepal

Tomato-Local

Error Correction:	D(POK)	D(KAL)	D(BUT)
CointEq (1)	0.0433 (0.048) [0.899]	0.3017 (0.067) [4.439]	-0.0719 (0.067) [-1.584]

Potato-Red

Error Correction:	D(BIR)	D(DHA)	D(KAL)	D(NAR)	D(NEP)	D(POK)	D(KAN)	D(SUR)	D(BUT)
CointEq (1)	-0.279 (0.087) [-3.21]	0.061 (0.086) [0.71]	0.108 (0.060) [1.78]	-0.007 (0.080) [-0.08]	0.228 (0.100) [2.27]	0.051 (0.066) [0.77]	-0.054 (0.097) [-0.55]	0.255 (0.082) [3.08]	0.312 (0.092) [3.39]
CointEq (2)	-0.033 (0.029) [-1.14]	-0.108 (0.029) [-3.72]	-0.090 (0.020) [-4.45]	-0.056 (0.027) [-4.44]	0.040 (0.033) [1.21]	-0.056 (0.022) [-2.50]	0.022 (0.032) [0.69]	-0.083 (0.027) [-3.01]	0.013 (0.030) [0.44]
CointEq (3)	0.046 (0.076) [-1.14]	-0.01 (0.075) [-0.18]	-0.211 (0.053) [-3.97]	0.141 (0.070) [2.00]	0.005 (0.088) [0.06]	0.117 (0.058) [2.00]	-0.157 (0.085) [-1.85]	-0.160 (0.072) [-2.20]	0.035 (0.080) [0.43]
CointEq (4)	-0.124 (0.069) [-1.79]	-0.126 (0.068) [-1.83]	-0.011 (0.048) [-0.23]	-0.170 (0.064) [-2.64]	-0.019 (0.079) [-0.24]	-0.211 (0.053) [-3.98]	0.101 (0.077) [1.31]	0.019 (0.065) [0.29]	0.149 (0.073) [2.04]

Onion-Dry

Error Correction:	D(BIR)	D(DHA)	D(KAL)	D(NAR)	D(NEP)	D(POK)	D(KAN)	D(SUR)	D(BUT)	Error Correction:
CointEq (1)	-0.115 (0.185) [-0.63]	0.491 (0.170) [2.88]	0.604 (0.16) [3.73]	-0.531 (0.12) [-4.22]	0.267 (0.19) [1.40]	-0.112 (0.15) [-0.73]	0.427 (0.22) [1.96]	-0.034 (0.22) [-0.15]	0.315 (0.17) [1.79]	0.487 (0.17) [2.84]
CointEq (2)	-0.171 (0.082) [-2.07]	-0.414 (0.076) [-5.43]	-0.085 (0.07) [-1.17]	0.885 (0.56) [2.64]	-0.035 (0.08) [-0.41]	-0.242 (0.06) [-3.56]	-0.127 (0.10) [-1.26]	-0.043 (0.09) [-0.43]	-0.310 (0.07) [-3.93]	-0.280 (0.07) [-3.66]

Note: All the figures in parentheses are standard error and figures in brackets are *t*-values.

Table 7. Estimation of short-run dynamics of retail prices of major vegetables in Nepal

Onion-Dry									
Error Correction:	D(BIR)	D(DHA)	D(KAL)	D(NAR)	D(NEP)	D(POK)	D(KAN)	D(SUR)	D(BUT)	D(PAL)
CointEq (1)	0.0039 (0.134) [0.029]	-0.7310 (0.134) [-5.455]	-0.376 (0.128) [-2.934]	-0.054 (0.155) [-0.349]	0.009 (0.118) [0.077]	0.117 (0.114) [1.029]	-0.342 (0.136) [-2.503]	-0.005 (0.156) [-0.032]	-0.000 (0.143) [-0.004]	-0.371 (0.112) [-3.291]

Cabbage									
Error Correction:	D(BIR)	D(DHA)	D(KAL)	D(NAR)	D(NEP)	D(POK)	D(KAN)	D(SUR)	D(BUT)	D(PAL)
CointEq (1)	0.1867 (0.073) [2.537]	-0.1680 (0.068) [-2.499]	-0.6886 (0.134) [-5.132]	-0.2197 (0.109) [2.005]	0.1157 (0.104) [1.106]	-0.0818 (0.109) [-0.746]	0.0206 (0.092) [0.221]	-0.2363 (0.104) [-2.268]	0.1003 (0.084) [1.192]	0.1875 (0.116) [1.610]

Note: All the figures in parentheses are standard error and figures in brackets are *t*-values.

error-correction reveal a very weak association between these vegetable markets in the short run. Thus, it may be concluded from the above analysis that while prices are tied together in the long run, they drift apart in the short run because of the unavailability of information and lack of quicker dissemination of available information.

CONCLUSION AND POLICY IMPLICATIONS

Market integration reflects price linkages to test and measure the extent of trade between two markets. Using weekly wholesale price and retail price data for three years, this paper analyzed the spatial integration of vegetable markets in Nepal. From the results, it was observed that the wholesale markets of very perishable crops like local tomato had integration in the long run. This may be due to the fact that the production of local tomato is more concentrated in hills. The concentrated production urges traders and consumers to focus on production and marketing, and this makes the prices in other markets move with the prices of production areas to a greater degree. Similarly, the wholesale markets of red potato and dry onion were found to be highly

integrated, except the wholesale markets of both situated in the Far-western region. These were found to be segmented with the markets of other development regions and signifies that the longer the distance, the lesser the integration. The perishable nature, change, and slow transfer of prices of cabbage and cauliflower might be the underlying reasons for poorer wholesale market integration of these two vegetables. Further, there was an absence of cointegration among the retail markets of local tomato, red potato, and cauliflower whereas integration was observed in retail markets of dry onion and cabbage. These results show that due to lack of available, timely information on price, lack of transportation facilities, product characteristics, and large distance among the markets made them segmented. The price transmission of local tomato was found to be lacking in the short run with only Kalimati market as the strongest follower of change in price. Similarly, the short-run price transmission of red potato and dry onion was insignificant. The reason might be the unavailability of adequate information, lack of dissemination of available information, and transportation conditions. In Nepal, it usually takes a long time to transport commodities

from one province to another because of limited transportation facilities. These factors prevent the traders from responding immediately to price changes in other markets.

The results of this study show that vegetable markets in Nepal are integrated in the long run. However, the degree of short-run market integration is rather low. Therefore, in vegetable markets, the transmission of price information is slow and price changes across regions are not responsive to each other. To make the vegetable markets in Nepal more efficient, there is a need to focus on building an improved market information system—one that is able to disseminate timely market information about price, demand, and supply of products to enable producers, traders, and consumers to make proper production and marketing decisions. The monitoring and forecasting results on agricultural products supply, demand, and price of the Information Centre of Ministry of Agriculture and Cooperatives of Nepal and relative units like the Marketing Development Board should be shared timely and accurately to producers, traders, and consumers through various communication media. This can help farmers and traders understand the trends of production and marketing. In turn, they will be able to make better decisions as well as realize higher returns in the process and thus help consumers to get the product at a reliable price. The government is also required to create market infrastructure facilities such as transportation, warehousing, and processing, among others.

REFERENCES

Alexander, C., and J. Wyeth. 1994. "Cointegration and Market Integration: An Application to the Indonesian Rice Market." Journal of Development Studies 30 (2): 303-328.

Asche, F., H. Bremnes, and C.R. Wessells. 1999. "Product Aggregation, Market Integration, and Relationships between Prices: An Application to World Salmon Markets." American Journal of Agricultural Economics 81 (3): 568-581.

Baulch, B. 1997. "Transfer Costs, Spatial Arbritage, and Testing for Food Market Integration." *American Journal of Agricultural Economics* 79 (2): 477-487.

Blyn, G. 1973. "Price Series Correlation as a measure of Market Integration." I*ndian Journal of Agricultural Economics* 28 (1): 56-59.

Cummings, R.W. 1967. *Pricing Efficiency in the Indian Wheat Market*. New Delhi: Impex.

Dahlgram, R.A., and S.C. Blank. 1992. "Evaluating the Integration of Continuous and Discontinuous Markets." *American Journal of Agricultural Economics* 74 (2): 469-479.

Dercon, S. 1995. "On Market Integation and Liberalisation: Method and Application to Ethiopia." *Journal of Development Studies* 32 (1): 112-143.

Dickey, D.A., and W.A. Fuller. 1979. "Distribution of Estimators for Autoregressive Time Series with Unit Roots. *Journal of the American Statistical Association* 74 (366): 112-143.

Dickey, D.A., and W.A. Fuller. 1981. "Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root." *Econometrica* 49 (4): 1057-1072.

Enders, Walter. 1995. *Applied Econometric Time Series*. USA: John Wiley and Sons Inc.

Engle, R.F., and C.W.J. Granger. 1987. "Cointegration and Error Correction: Representation, Estimation and Testing." *Econometrica* 55 (2): 251-276.

Faminow, M.D., and B.L. Benson. 1990. "Integration of Spatial Markets." *American Journal of Agricultural Economics* 72 (1): 49-62.

Goletti, F., R. Ahmed, and N. Fraid. 1995, "Structural Determinants of Market Integration: The Case of Rice Markets in Bangladesh." *The Developing Economies* 33 (2): 185-202.

Goodwin, B.K., and T.C. Schroeder. 1991 "Cointegration Tests and Spatial Price Linkages in Regional Cattle Markets." *American Journal of Agricultural Economics* 73 (2): 452-464.

Harriss, B. 1979. "There is Method in My Madness: Or Is It Vice Versa? Measuring Agricultural Market Performance." *Food Research Institute Studies* 17 (2): 197-218.

Heytens, P.J. 1986. "Testing Market Integration." *Food Research Institute Studies* 20 (1): 25-41.

Ismet, M., A.P. Barkley, and R.V. Llewelyn. 1998. "Government Intervention and Market Integration in Indonesian Rice Markets." *Agricultural Economics* 19 (3): 283-295.

Johansen, S. 1988. "Statistical Analysis of Cointegration Vectors." *Journal of Economic Dynamics and Control* 12 (2-3): 231-254.

Johansen, S., and K. Juselius. 1990. "Maximum Likelihood Estimation and Inference on Cointegration with Application to the Demand for Money." *Oxford Bulletin of Economics and Statistics* 52 (2): 169-210.

Lele, U.J. 1967. "Market Integration: A Study of Sorghum Prices in Western India." *Journal of Farm Economics* 49 (1): 147-159.

Lele, U.J. 1971. *Foodgrain Marketing in India: Private Performance and Public Policy*. Ithaca, New York: Cornell University Press.

Palaskas, T.B., and B. Harriss-White. 1993. "Testing Market Integration: New Approach with Case Material from the West Bengal Food Economy." *Journal of Development Studies* 30 (1): 1-57.

Ravallion, M. 1986. "Testing Market Integration." *American Journal of Agricultural Economics* 68 (1): 102-109.

Ravallion, M. 1987. *Markets and Famines*. Oxford: Clarendon Press.

Tomek, W.G., and K.L. Robinson. 1990. *Agricultural Product Prices*. Ithaca, New York: Cornell University Press.