Transfer Costs and Spatial Price Efficiency in the Nepalese Tomato Markets

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Introduction

The spatial price analysis is one of the important areas to study the structure of markets and how they perform (Ravallion, 1986). The need for such a study arises because agricultural commodities are bulky, their production is seasonal, and production and consumption points are spatially dispersed. As a result, the transportation of a commodity from one market to another is costly and requires special efforts (Sexton et al, 1991). Transfer cost, which consists of the costs of transferring goods from one market to another, is an important component in spatial price analysis.

In a study of spatial markets, the concept of pricing efficiency is distinguished from the concept of market integration. The pricing efficiency is the price-based notion of equilibrium, whereas the market integration is the flow-based indicator of tradability (Barrett, 2001). The efficiency is associated with a condition in which the marginal benefits from trade are zero. If trade exists between two markets and trade volume is unregulated, the process of arbitrage is expected to lead to a spatial equilibrium, such that the price spread between two markets is equal to the transfer costs. However, when the trade volume reaches some ceiling value, the price spread between the markets is bounded below by the cost of arbitrage between these markets (Barrette, 2001). In the case of domestic markets, especially in developing countries like Nepal, the volume of trade is unrestricted. In such situations, we expect the price spread between two markets to be bounded from above by the cost of arbitrage between the markets. If an equilibrium condition holds, it is said that the two spatially separated markets are integrated (Goodwin and Schroeder, 1990), or the law of one price (LOP) prevails between the two markets (Zanias, 1999; Sexton et al, 1991), or the markets are spatially price efficient (Tomek and Robinson, 1990). Otherwise, the markets may have some constraints on efficient arbitrage such as trade barriers and information asymmetry (Ravallion, 1986; Barrett, 2001), or imperfect competition in one or more markets (Faminow and Benson, 1990). Hence, the study of spatial market relationships provides the extent to which markets are related and efficient in pricing. If trade relates the two markets of interest, the shock in prices in the central market (surplus market) is expected to transmit to the local market (deficit market) as quickly as possible.

A great deal of advancement has been made to examine the way spatially separated markets are related. The techniques range from a simple regression model to co-integration models. However, most of the earlier regression and co-integration based tests are criticized for not taking into account the transfer costs (Goodwin and Piggott, 2001; Baulch, 1997; Sexton et al, 1991; Barrett and Li, 2002). In literatures, the importance of transfer costs in the spatial analysis is well recognized. The general consensus behind not considering transfer costs in the analysis is the lack of suitable data on transfer costs. Seasonality is another component often ignored. Zanias (1999) argues that the testing of market integration in the absence of seasonality may give a spurious result.

In this study, we analyze the spatial pricing efficiency, taking into account both transfer costs and seasonality components, and considering two spatially separated markets for tomatoes in Nepal. Specifically, we are interested in estimating the speed of price adjustment in Besishahar market, considered as a deficit market, in response to the price shocks of Narayangarh central market, considered as a surplus market. We are also interested in examining the efficiency of spatial arbitrage between these two markets.

The paper is structured as follows. The following section briefly introduces two selected markets in Nepal. Then, we will review the methods of analyzing the spatial price relationships.

This will be followed by a description of data and the model specifications. Finally, we describe the results and conclude our findings.

Brief Introduction to the Selected Markets in Nepal

Nepal is a small country with an area of 147,180 square kilometers and a population of about 24 million. The country is located between China in the north and India in the south, east and west (Figure 1). Home to Mount Everest, Nepal is located almost entirely at the foothills of Mountains. Ecologically, it is composed of three regions: Mountains, Hills, and Terai. The Mountain region runs along the entire northern boundary characterized by rugged terrain and very sparsely distributed population. The Hills run east to west parallel to the Himalayas. The flat plain of Terai also extends from east to west in the southern corridor along the border with India. This region is known for its fertile land, which is well suited for agriculture. The country is characterized by wider variations in climate, and thus in production possibilities, despite its small size.

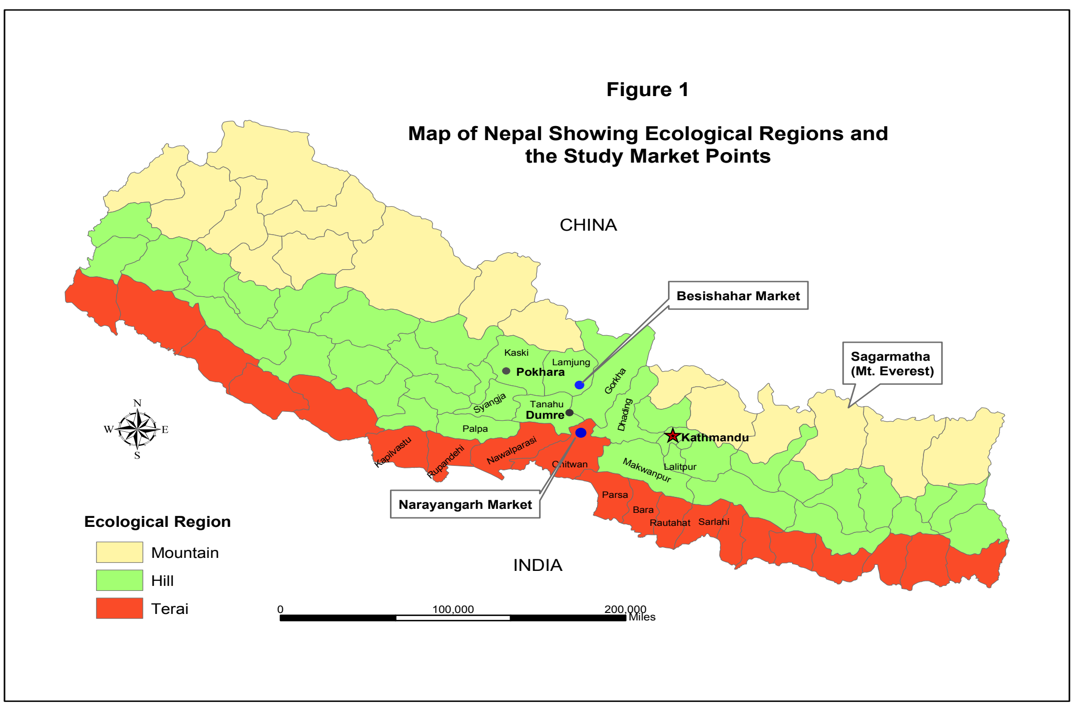

Figure 1

Map of Nepal Showing Ecological Regions and the Study Market Points

Nepal is predominantly an agricultural-based country. The agriculture sector employs about 80% of the active population. The contribution of the agricultural sector to the national GDP is over 40%. As most of the land is covered by the mountains and the hills, only about 17% of the land is suitable for cultivation. The mountain region is suitable for livestock production. The hills are climatically suitable for fruits and vegetable production. Terai is best suited for cereals, oilseeds and vegetables. The diversity in the production potentials and climatic variations allow it to produce most vegetables year the round. Vegetable production is mainly concentrated in the Terai plains and some irrigated area of foothills.

Vegetable farming is one of the important sectors contributing to the growth of Nepal's national income. Realizing the potential of vegetable farming in the country, the government of Nepal has emphasized the commercial production of vegetables in various major potential pockets along the road corridors (HMGN and ADB, 1995). Nevertheless, the country is still heavily dependent on imports of vegetables from India. It is reported that two-thirds of the vegetables consumed in Nepal is dependent on imports (HMG/N, 1998). The vegetable marketing system in Nepal is characterized by poorly organized markets, lack of a mechanism for price and market information, and inflated marketing margins (Gurung et al 1996). One of the major constraints of efficient vegetable marketing in Nepal is the unavailability of price and market information, which is important not only for planning a production but also for efficient trading. In most cases, producers are prevented from fetching fair prices of their products. They have been subject to the prices set by limited and relatively better-informed traders (CEPEREAD, 1997). Having considered the importance of market information, the government of Nepal has focused on the collection and dissemination of market information via different media such as radio, and display of information on the boards in major market centers (HMG/N, 1998).

However, to what extent such efforts have been helpful to improve the vegetable marketing systems in Nepal is still a matter of investigation. This paper is stemmed from this gap in information.

In this study, we attempt to provide evidence about the performance of markets, taking into account the prices of tomatoes, one of the most widely consumed vegetables in the country. We select two markets: Narayangarh and Besishahar markets (Figure 1). Narayangarh market (central market) is the main market center in Chitwan district, which is located in the south central plain (Terai region) of Nepal. After the eradication of Malaria in the 1950s, Chitwan has been the main destination for migrants from neighboring hills and all over the country. This market is well linked to major cities of the country including Katmandu the capital city, and Pokhara a tourist hub. Because of its centrality in position, this market is becoming one of the major wholesale markets to supply vegetables to different markets of Nepal. The major districts linking Narayangarh as both a source and a recipient of vegetables are presented in Figure 1. The outskirt of Narayangarh market is growing at a faster rate for the commercial production of vegetables.

Besishahar is the headquarters of Lamjung district. It is located in the middle hills about 112 kilometers to the north of Narayangarh. The Besishahar market is emerging as one of the growing markets for vegetables after a recently built all weather roads. Although, the areas along the road corridors to Besishahar are suited to a wide range of vegetables production, commercial production is still a new enterprise to this area. Most of the demand for vegetables in Besishahar is supplied from the Terai such as Narayangarh and a few recently emerging small production pockets around it. It is observed that of the total number of tomatoes traded in Besishahar, 67% were traded from the Narayangarh market. The direction of trade flow is unidirectional - from

Narayangarh to Besishahar. There is a small intermediate market (Dumre) between Besishahar and Narayangarh from where traders of Besishahar can import vegetables. However, as the Dumre market is mainly served by Narayangarh market, and there is a direct and regular bus services between Narayangarh and Besishahar, traders in Besishahar find it cheaper to buy vegetables directly from Narayangarh.

The bus service between the Narayangarh and Beshisahar markets serves as the main mode of transporting vegetables. Vegetables are generally transported on the top of buses. The packaging facilities of tomatoes are very traditional. The bamboo baskets cushioned with rice straw, that hold 25 to 50 Kg of tomatoes is the main packaging facility. In both the markets, at retail exchanges, tomatoes are sold open without any packaging.

Estimating Spatial Price Relationship

Various approaches have been used to study spatial price relationships. The estimation of static bi-variate correlation coefficient is a traditional method of measuring the spatial price relationships. From a modeling perspective, the approaches to spatial price analysis and market integration can be grouped into two categories. In the first group is the law of one price (LOP) and Ravallion model. These approaches are based on co-movement of prices. The second approach is the co-integration test. This allows prices to be determined simultaneously and permits seasonal variation in transfer costs.

One of the approaches to test the LOP is regressing the price of one market on the price of another market and test whether the slope coefficient is 1. Considering the two markets: market 1 as local market and market 0 as central market, the basic model for it is as follows.

$$P_{1t} = b_0 + b_1 P_{0t} + u_t$$

P1 and P0 are the prices in two markets expressed in logarithmic form. Assuming that products are homogenous and there is an absence of transportation cost, the LOP holds if b_1=1 and b_0 =0. However, the existence of transfer costs cannot be ignored. Transfer costs may vary with the lapse of time, so the ignorance of it may affect the LOP test. Moreover, Ravallion (1986) states that such models represent only a simple radial configuration of markets linking one market directly with another market. Such a model also does not take into account the intermediate markets via which a local market trade with the central market. He further argues that this model provides limited information about the market integration. Ravallion extended the bi-variate method to a dynamic model, which captures both short-run and long run dynamic adjustment processes. It is based on the behavioral assumption that it requires a period time to adjust before the price shocks in the central market are transmitted to the local market. The model involves regressing the price of one market at time t to the lagged price and the price of another market at time t.

$$P^1{}_t = \alpha P^1{}_{t-1} + \beta P^0{}_t + e_t$$

The hypothesis for short run market integration is given by β =1. It indicates that the price shocks in the central market are immediately transmitted to the local market price. While for long run market integration- in which the market prices are constant over time and is not disturbed by the shocks in the central market- it requires that $\alpha+\beta= 1$.

With the advancement in time series modeling, the co-integration approach has been widely used, using time series data on prices that exhibit random walk. Generally, if two markets are integrated, the prices of the two markets are considered to be co-integrated. However, McNew (1996) argues that the variables that maintain economic equilibrium do not necessarily satisfy a co-integrating relationship because of transfer costs. Recognizing the importance of transaction costs, researchers have applied switching models that endogenize the transfer costs in the model and account for multiple regimes. Bausch (1997) used the parity bounds model (PBM), which takes into account the transfer costs. In this model, the transfer costs determine the parity bounds within which the commodity in two markets may vary independently. This model distinguishes three possible trade regimes: (a) at the parity bounds - the spatial price differential is equal to the transfer costs; (b) inside parity bounds - in which price differentials are less than the transfer costs; and (c) outside parity bounds- in which price differential is greater than the transfer costs. The higher the incidence of outside parity bounds the lower the market integration.

Another approach is switching regression systems, which are estimated using the maximum likelihood estimation technique (Spiller and Huang, 1986). In this case, the prices are not treated as the predetermined variables. The transfer costs are determined within the system, and the probability that markets are integrated is allowed to vary continuously. Sexton et al. (1991) applied the same method with an extension to study the effect of lagged price, which allows for determining the probability of efficient arbitrage, glut, and shortage for a given market. Both Spiller & Huang (1986) and Sexton et al (1991) have assumed a continuous trade and the direction of trade flow as constant. The discontinuous trade and time varying non-stationary transaction costs are the major problems that affect the spatial price analysis (Barrett and Li, 2002).

Recently, Barrett and Li (2002) introduced a new approach based on the MLE called a mixture distribution model. This model takes into account the transfer costs, prices and trade flows. The model distinguishes between the market integration and market equilibrium. The market integration is considered as the tradability of commodities between spatial markets regardless of whether spatial market equilibrium exists or not. The competitive market equilibrium involves a price-based notion of efficiency (Barrett, 2001; Barrett and Li, 2002). Barrett and Li's distribution mixture model uses multiple international markets. The model takes into account bi-directional trade flows, discontinuity in trade, and the time varying non-stationary transaction costs. Based on whether or not trade exists, the model looks at the relationships between price spread, transfer costs and trade flows by distinguishing six switching regimes. These regimes are used to explain the four potential market conditions: perfect integration, segmented equilibrium, imperfect integration, and segmented disequilibrium.

Though the importance of transfer costs in spatial price analysis is well recognized, the lack of suitable data on transfer costs constrains the modeling process. Getting a reliable data on transfer cost over the selected period of time is a problem. Moreover, most of these models are based on specific assumptions and have ignored the seasonality in model specification. Agricultural commodities being seasonal in production, the prices of commodities and price spread are expected to vary seasonally.

Empirical Model

As stated in their paper, Barrett and Li's mixture distribution model using the maximum likelihood estimation technique is the first method that considered price, transfer costs and trade flows. They use multiple international markets taking into account bidirectional and continuous trade flows, non-stationary prices, and transfer costs. The specification of the econometric model is dependent on the assumption of the structure of the spatial markets. The model we present is a simple restricted model, in that it considers only two domestic markets without considering the intermediate markets. The pattern of trade is clearly unidirectional from the central market to the local market. The model we use is an extension of Ravallion's dynamic model. Our model considers prices, transfer costs, and the seasonality using Fourier decomposition. The econometric model for the estimation is as follows.

$$\log P_{1t} = F_t + k(\log P_{1t-1} - \hat{F}_{t-1}) + e_t \qquad (1)$$

$$\text{Where, } F_t = \beta_0 + \beta_1 T + \beta_2 LogP_{0t} + \beta_3 ST_t + \beta_4 CT_t + \beta_5 RTC_t \qquad (2)$$

t = 1, 2, …,N

In equation (1), $LogP_{1t}$ is the log of retail price of tomatoes at the Besishahar local market, specified as the endogenous variable, measured in Nepali rupees at time t. k is the price adjustment coefficient, which takes values between 0 and 1. If $k = 0$, there is no adjustment in price in the local market in response to a price change in the central market. If $0 < k < 1$, there is gradual adjustment in price and if $k = 1$ adjustment in price is perfect. So the coefficient k provides the extent to which two markets are spatially related. $\log P_{1t-1}$ is the log of price of tomatoes in the central market with one time period lag. $\hat{F}_{t-1}$ is one period lag of estimated F_t. e_t is the disturbance term, which is assumed to be identically and independently distributed with mean zero and constant variance in all the observations. Similarly, it is assumed that explanatory variables are non-stochastic and not related to each other.

In the equation (2), T represents the time specified to measure the inflation rate. The inflation rate is expected to increase with a lapse of time. $LogP_{0t}$ is the log of tomato retail price in the Narayangarh central market at time t. Seasonality is another time dimension that affects the price of vegetables and the price spread between two markets. Various methods are used to estimate the seasonal effects. One of these methods is a Fourier analysis, which encompass the smooth movement of price using the sine functions. For the estimation of a degree of seasonality, we use the procedure used by Washington et al (2002) as follows.

$$\log P_{1t} = A \quad Sin\left[\left(\frac{ft}{n}\right)2\pi + \phi\right] + e_t$$

Here, $\log P_{1t}$ is the dependent variable. *A* represents the amplitude of sine waved. *f* is the number times the sine wave completed over the span of one year. The data shows that the sine wave completes once in a one-year period. So, the value of *f* is set at 1. *t* is a time index , *n* is the number of observations and ϕ is the phase angle which is the shift of the sine wave. For solving this non-linear problem, the function is linearized as the following equation.

$$\log P_{1t} = A \quad \cos\phi \quad \sin\left[\left(\frac{ft}{n}\right)2\pi\right] + A \quad \sin\phi \quad \cos\left[\left(\frac{ft}{n}\right)2\pi\right] + e_t$$

Consider A cos $\phi=\beta_3$ and A sin $\phi=\beta_4$. With this, and assuming that the dependent variable is not equal to zero at its mean, we have the following equation, which can be estimated using OLS.

$$\log P_{1t} = \beta_0 + \beta_3 \sin\left[\left(\frac{ft}{n}\right)2\pi\right] + \beta_4 \cos\left[\left(\frac{ft}{n}\right)2\pi\right] + e_t$$

whe`re the amplitude of sine wave is obtained as $A = \sqrt{\beta_3^2 + \beta_4^2}$

In the estimation of relationships, the seasonality components are assigned as follows (equation 2).

$$ST = \sin\left[\left(\frac{ft}{n}\right)2\pi\right] \qquad CT = \cos\left[\left(\frac{ft}{n}\right)2\pi\right]$$

In order to test if there is a seasonal effect, the amplitude coefficient is tested against zero as follows.

$$H_0: \quad \sqrt{\beta_3^2 + \beta_4^2} = 0 \qquad H_A: \quad \sqrt{\beta_3^2 + \beta_4^2} \neq 0$$

It is assumed that the price relationship between two trading markets is mainly determined by the transfer cost (TC). Under the condition that the commodity is homogenous and two markets are trading, the efficient commodity arbitrage is expected to lead to an equilibrium condition where the price difference is just equal to the transport and other transfer costs between the markets. If the price difference is greater than the transfer cost, the spatial arbitrage continues unless the traders find no incentive to trade between the markets (Fackler and Goodwin, 1999). This can be expressed as, $P_1 - P_0 \geq TC$. Where, P_1 = price of the commodity at the local market and P_0 is the price of the commodity at the central market. The introduction of the transfer cost in the estimation allows determining if a local market is spatially price efficient with reference to the central market.

In the specification of the model, the transfer cost is specified as the relative transfer cost (RTS), the ratio of transfer cost to retail price at Besishahar market i.e., TC/P_1. If the price difference between two markets is due to transfer costs, the estimate for RTC variable would be equal to one and the local market would be considered spatially price efficient with respect to the central market. If the value is not equal to 1, then the difference in the price between two markets is attributed to other factors as well.

For the purpose of the estimation of the model, an ordinary least square (OLS) technique is used. The t-test is used to test the hypothesis for individual coefficient. For testing the model as a whole, we use Wald Chi-squared test. In order to determine if the price difference between two trading markets is due to transportation cost, the RTC coefficients are tested against 1 using the Wald test. Similarly, to test if there is seasonal effect, the amplitude of sine wave, A is tested against zero.

Data

The data we use comes from the research project entitled "Marketing System of Vegetables along the Dumre-Beshisahar Road Heads: Socioeconomic Implications for Market Oriented Production" conducted during Dec 1999-Dec 2002 in Nepal. The data was collected from Narayangarh and Beshishahar market points by the Forum for Rural Welfare through Agricultural Research and Development (FORWARD), one of the national Non-Governmental Organizations (NGO) in the country.

The data were collected by trained enumerators using a structured interview format. Collection of time series data such that the date of data collection corresponds across the interest markets is difficult and challenging and demands a special arrangement during the data collection. Absence of such time consistent data across the markets leads us to use of aggregated data, such as that aggregated by months.

The data we use in this study is unique in terms of methodology of data collection that removes aggregation problems. In both of the study markets, the data were collected at exactly the same time in three days intervals. Days for data collection were fixed on the 1st, 3rd, 7th, 10th, 13th, 16th, 19th, 22th, 25th and 28th day of every Nepali month. In this way, in each month for each market, 10 sets of data points were created. We expect that such a synchronization of the day of data collection across the study markets give a more realistic picture of the functioning and performance of the markets under study. For this study, we used two years data, from December of 1999 to December of 2001. The data consists of 240 observations for each market.

In each market, three vegetable retailers representing different locations of the markets were selected for the periodic survey. One of the jobs of the site-based interviewer was to note the price of vegetables by observing the market. Data from a few other retailers were also informally collected to make sure that the information obtained has a minimum of error. For the purpose of this study, the prices recorded in a specific day within the market are averaged. However, the transfer costs incurred for the total volume of trade that took place between the last visit and current visit were recorded and reported as average transfer cost per kilogram of tomatoes.

Results

Table 1 presents summary statistics of the important variables used in the analysis. On average, the retail price of tomatoes in Besishahar market is about Rs 26 per kilogram. This price is 37% higher than the average retail price in Narayangarh market. This indicates a substantially higher price spread between these two markets even after the market loss and the transportation costs are taken into account. The market loss is not included in the analysis. At Besishahar market, average market loss between buying and selling of vegetables by retailers is 7.2% of the total volume traded.

Table 1:Summary statistics (mean + standard error) of selected variables for tomatoes by market

Market	Obs.	Retail price (Rs/Kg)	Transfer cost (Rs/Kg)
Besishahar	218	25.73 ± 0.49	1.22 ± 0.010
Narayangarh	218	18.71 ± 0.46	NA

Conversion: 1$=Rs 77.00 1 Kg = 2.2 Pounds

The cost of transferring tomatoes from Narayangarh to Besishahar market, on average, is Rs 1.2 per kilogram. This cost includes, transportation fare, loading and unloading charges, and the municipality tariff. There is a little variation in transfer costs. Such a small variation in the transfer costs is because of two main reasons. First, vegetables are transported by bus from Narayangarh to Besishahar. The bus fare usually remains the same for a considerable period of time unless there is a significant hike in gasoline prices. Second, this might also be associated with the volume of transaction. Normally, we expect a decrease in per unit cost of transportation with an increase in the volume of trade. However, in this specific case, due to a lack of storage facilities, the volume of a trade tends to be smaller and less varied.

Table 2 presents the OLS estimates for the log of retail price of tomatoes in Besishahar local market considering three different specifications. The time component is controlled in all three models. The "Model I" represents a basic lag model without including transfer costs and seasonal components in the estimation. As shown by the results, adjusted R^2 value indicates a fairly high (83%) explanatory power of the model. Similarly, the Wald test result shows that the model is significantly different from zero.

Table 2: OLS estimates for log of retail price of tomatoes in Besishahar market

Parameter	Model I		Model II		Model III	
	Estimate	*Std.Error*	*Estimate*	*Std.Error*	*Estimate*	*Std.Error*
Intercept (b0)	2.6522***	0.1942	2.6519***	0.1946	2.8054***	0.1701
Time (b1)	0.0019*	0.0009	0.0019*	0.0009	0.0005	0.0004
logNP (b2)	0.1064*	0.0555	0.1061*	0.0556	0.1186*	0.0554
ST (b3)		0.0348			-0.2596***	0.0451
CT (b4)					0.1117**	0.0362
RTC (b5)			0.003	0.0096	0.0044	0.0099
k	0.8628***	0.0348	0.8627***	0.0349	0.6725***	0.0514
Adj. R^2	0.8301		0.8302		84.72	
Durbin d	2.368		2.3719		2.1722	
Durbin h	-2.72*		-3.20*		-1.95	
Wald test results for hypothesis tests						
b2=1	259.47***		258.35***		253.51***	
b5=1			10793***		9986.6***	
Model	1614.9***		2607.5***		16340***	
A=0					38.81***	

***=Significant at 0.1% level; **= significant at 1% level; *= significant at 5% level

Model I: Model without RTC and seasonality components.
Model II: Model including RTC, but without seasonality components.
Model III: Model including both RTC and seasonality components.

LogNP= Log of Narayangarh retail price
K= Adjustment coefficient
B2 =Coefficient estimate for log NP
B5= Coefficient estimate for relative transportation costs
A= Amplitude of sine wave

The coefficient for the intercept is also highly significant, implying that the regression line does not pass through the origin, which is reasonable. The estimated coefficient of time is highly significant. While keeping other variables constant, the inflation rate attributed to tomatoes on average is 10 times (because there are 10 observations in each month) the coefficient (0.0019), which is 2% per month. The coefficient for the Narayangarh price is 0.10 ($p<.05$). It shows that about 10% of the price shocks in the Narayangarh market are transmitted to the Besishahar market on the same day. We expect that such a transmission of shock is more importantly due to the efforts of the traders of telephone communication rather than other information sources such as government dissemination of price information via radio and price reports. Similarly, the price adjustment coefficient is highly different from zero ($p<0.001$). It is observed that, on average, 86% of the shocks in prices in the Narayangarh market are transmitted to the Beisishahar market within a one-time period i.e., three days. This finding indicates that the pricing of tomatoes in Besishahar is highly responsive to the change in the price at the Narayangarh market and its last period price.

In time series analyses, we normally expect to see an autocorrelation problem. Given that the model we specified is a lag model, we estimated the Durbin h statistics using the Durbin d values obtained as suggested in Greene (2002). The Durbin h value is significant ($p<0.05$) exhibiting an autocorrelation problem in the data. This could be due to the omission of important explanatory variables such as transfer costs and seasonality. This could be also due to some missing observations in the data. The results presented are based on the 218 observations while the expected complete number of observations is 240. So, we also ran model imputing the missing observations. The imputed value was obtained as an average of two upper and two lower observations. However, the results obtained with completed observations did not improve the model and the autocorrelation problem. The scattered missing observations without clustering into a specific point in the time series could be the reason for this result. Therefore, we decided to run further models with the original data without imputation for missing data.

The Model-II represents an extended model of Model-I with an addition of the relative transfer cost (RTC) variable in it. The inclusion of the RTC does not improve the model. The transfer costs have a negligible influence in the price spread between the two markets. This is also evident from the Wald test result in which the RTC coefficient is significantly different from 1 ($p<0.001$). Under the situation that price differential between two markets is equal to transfer costs; we expect the coefficient to be equal to 1. This indicates that the spatial arbitrage is not complete, showing inefficiency in the pricing in the local market with respect to the price prevailing in the central market. The specification of Model-II also does not improve the problem of autocorrelation either.

Considering that seasonality is one of the important components that affect both prices and price spreads between the markets, we further estimated an extended model including seasonality components in it. The Model-III presents the results of the extended model including both RTC and seasonal components. As shown in Table 2, the model is highly significant with an explanatory power of 84%. The coefficient for the log of the Narayangarh price is highly significant ($p<0.05$). It shows that about 12% of the price shocks in the Narayangarh market are transmitted to the Besishahar market on the same day. Approximately 67% of the shocks are transmitted within three days.

Both of the seasonality components are highly significant. In order to test if there is a significant effect of seasonality, the amplitude of the sine wave was tested against zero using the Wand test. The amplitude coefficient obtained is significantly different from zero, showing that there is a strong influence of seasonality in the price spread between the two markets. The results clearly indicate spatial analysis in the absence of seasonality produces a bias estimate of adjustment coefficient. The inclusion of seasonality also gets rid of the problem of autocorrelation. Generally, we expect the sign of the Durbin h to be positive. It is not clear why the sign is negative.

In Model-III also, the coefficient for the RTC is not significantly different from zero. However, it is significantly different from 1. This result is consistent in all three models indicating that the transfer costs have very little contribution to the price spread between these two specific markets. Nevertheless, the inclusion of transfer costs in the model provides important information about the performance of the markets. This allows us to know the extent that the transfer costs contribute to the price differential between the spatially distributed markets. Moreover, this information suggests that we seek a better understanding of the other factors that have a greater influence in the market inefficiency. It is interesting to note that although the transmission of price shocks from the Narayangarh market to the Besishahar market is fairly quick, spatial arbitrage is not complete. This provides a basis to think that there are stronger factors that influence the price difference between these two markets.

Conclusions

The study estimated the speed of price adjustment in the Besishahar market (local market) with reference to the Narayangarh market (central market) and estimated whether the spatial arbitrage is complete. Results show that the speed of price adjustment in the Besishahar market with response to price shocks in the Narayangarh market is about 80% in a period of three days. In the context of Nepal, where the vegetable markets are at their early phases of development, the result is encouraging. This may be attributed to both the availability of market information via government sources and traders' own efforts.

Although the price transmission from the central market to the local market is fairly quick, the process of spatial arbitrage is incomplete. This indicates that the Besishahar market is not spatially price efficient when compared with its main supplying market (i.e., P_1-P_0>TC). The hold of few incumbent traders and the barriers to the entry of new traders in Besishahar market can be the main factor for this market inefficiency. The local supply of tomatoes in Besishahar is very limited, so the supply of tomatoes in the Beshisahar market is dependent on the amount of imports by the traders. Tomatoes being a perishable commodity, and due to the lack of storage infrastructures, traders generally tend to limit the volume of import. They tend to bring a new supply once the old stock is close to exhausted. As there is not any government intervention that regulates the prices of vegetables, traders have the privilege to charge higher than efficient prices via manipulating the supply of tomatoes.

The results indicate that traders in Besishahar benefit from the government's efforts of market information collection and dissemination and the improvement in the marketing infrastructure such as road and telecommunication. However, the consumers in this market are paying higher prices. Results also showed that seasonality has a strong influence in the price spread of tomatoes between the markets. Results clearly show that spatial price analysis in the absence of seasonality tends to give a biased estimate for the adjustment coefficients.

The findings suggest that in addition to collection and dissemination of market information, the government should focus on the strategies that discourage the market power of limited traders and increase market competition. In this juncture, the initiation of cooperative markets can be one of the alternatives, which not only bring traders in to a stream of competitive markets, but also lower the transaction cost.

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