Supply Response Behavior of Nepalese Rice Producers: An Error Correction Model

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Abstract

An attempt was made to estimate the supply response of rice in Nepal by using an Error Correction Model. The short-run elasticity was negative while it was positive in the long run. Higher long-run elasticities are attributable to the conviction that farmers respond when they are certain that price changes are permanent. Further, the response to the Indian price is likely to decrease with the trade liberalization. Higher response to the supply of improved seed than to the prices implies that the subsistence farmers are less responsive to the changes in market prices than to the improvement of non-price factors.

Key words: Supply response, rice, error correction model, elasticity, subsistence farmer.

1. Introduction

Rice is the foremost food crop of Nepal and contributes more than 50 percent to the total edible cereal production (Bhujel *et al.*, 2006). Rice-based cropping system is predominated in the country (FAO, 2000) and it is cultivated in nearly 1.6 million hectares land, which is about 50 percent of total agricultural acreage. But, about 79 percent of its cultivation is under

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rain-fed farming system (MOAC, 2009). More than 75 percent of economically active agricultural population is engaged in rice farming at least for six months of a year. The average productivity is 2.9 tons per hectare but resource-rich farmers had registered the yield up to 4 to 5 tons per hectare during the monsoon season (Uprety, 2004). This wide gap in productivity suggests a huge potential to increase rice production and productivity. Productivity improvement after the Green Revolution is the engine for food production growth in the densely populated countries – China and India. Because of the mountain barrier in the Northern border with China, agricultural production in Nepal is mainly influenced by the Indian market. Indian farmers have been producing rice at low cost per unit as compared to the Nepalese rice growers (FAO, 2000) because of government subsidy on agricultural inputs (Papadementriou, 2000) and large scale operations. As a result, Nepalese farmers are encountering a lot of difficulties in competing with the Indian producers even in Nepalese markets. This has led to a notion in Nepalese farmers where they experience rice farming as less attractive and less profitable. Raising production surpluses is only possible through improving efficiency in production, and it asks for addressing both allocative as well as technical inefficiencies. However, the farmers' efforts to increase productivity depend on their responses to economic incentives in agriculture.

A meaningful improvement in economic structure requires re-evaluation of the agricultural policy which asks for a detailed knowledge of agricultural supply responsiveness. The supply responsiveness is an important issue in agricultural development economics since a farmer's responsiveness to economic incentives largely determines the contribution of agriculture to the economy. The response relation is a dynamic concept of supply theory and approximates the long-run relationship between the variables. Hence, an empirical knowledge of the structural parameters of supply is necessary for the use of agricultural policy instruments to affect agricultural activity (Mumbengegwi, 1990). There is a need of knowledge regarding responses of agricultural supply with respect to both price and non-price factors for effective agricultural policies to be implemented. Martin *et al.*, (1993), Muchapondwa (2008) and Tripathi (2008) reported that the agriculture sector in developing countries is low price responsive. But the non-price factors such as rural infrastructures, technology and limited access to credit are the main bottlenecks for agricultural development in such countries and the supply elasticities with respect to the non-price factors are high (Thiele, 2000). In case of Nepal, there are some studies, for example, Piya (2009) on supply response behavior in relation to price factor. But none of them have attempted to analyze the effect of Indian price on Nepalese rice production. While formulating and implementing agricultural policies, it is essential to consider the supply response estimates with respect to both Nepalese and Indian prices. The reason for this being more than 90 percent of total imported rice in Nepal is supplied by India (MOAC, 2009). Thus, the present study is motivated to analyze the supply response of rice with respect to both Nepalese and Indian prices, and the supply of improved seed. The study thus answers the research questions: (1) how does the price affect rice supply in Nepal? (2) How do non-price factors influence the rice supply in Nepal? and (3) What is the effect of Indian price on rice supply after the adoption of open-market and trade liberalization policies in Nepal?

The outline of this paper is organized as follows. Section 2 reviews the previous studies and presents preliminary results. Section 3 describes the theoretical model, method of estimating empirical model and the data requirements. Based on those considerations, section 4 presents the estimation results and discusses their economic implications for Nepalese rice supply. Conclusion and discussion are presented in section 5.

2. A Brief Review of Literature

2.1 Effect of Output Price and Non-Price Factors

Rice is the major staple food for Nepalese people and contributes the highest to the Nepalese economy. But rice cultivation is becoming less profitable and less attractive to the farmers because of a large increase in agricultural input prices as compared to the rice prices (Uprety, 2006). Bapna *et al.*, (1984) reported that the price elasticity for the short-run was 0.33 in

India. But in Sri Lanka, it was 0.09 and 0.11 for the short-run and long-run, respectively (Gunawardana and Oczkowski, 1992). Similarly, Cleaver and Schreiber (1994) estimated the short-run price elasticity to be 0.75 in the sub-Saharan Africa. Although it is the most common food among the Nepalese people, its production has not been able to satisfy the total requirement. IRIN (2008) reported that in recent years, about 25 percent of Nepal's food requirement was satisfied via the import from India, and postulated that the domestic price of rice should increase by 20 percent in order to stop imports of rice from India. Aryal (2008) argued that diversion of agricultural lands to bio-fuels production, increased consumption level and growing affluence in both neighboring countries - India and China- are the causes for the doubling of food prices over the last few years. HNS (2009) argued that one reason for the hiking of rice price in Nepal was the reduction of rice production in India. It is therefore necessary to increase domestic production; otherwise it could lead to a shortage of supply.

In addition to price factors, there are several non-price factors that determine the path of agricultural supply which include irrigation facilities, accessibility of roads, market facilities, access to credit, agro-extension services and availability of inputs (Mamingi, 1997). These factors are positively linked to agricultural supply and influence the supply response at varying magnitudes. Bhandari (2001) reported that the availability of shallow tube-well irrigation had a significant positive effect on improving rice productivity in the Terai region of Nepal. Murgai *et al.*, (2001) and Mamatzakis (2003) pointed out the need of public investments on education, roads, and research and extension to improve agricultural productivity and assure sustainability. Piya (2009) worked out to establish a recursive relationship between the production and market price of rice and the availability of irrigation facility. It was argued that the effect of irrigation is not discernable since the proportion of rice cultivated area to total irrigated land is already very high. Indeed, it is not convenient to incorporate all of these factors due to the non-availability of data and the quantification problems. In this scenario, this study was confined to considering only the usage of improved seed as non-price factor; and the prices of both Nepalese and Indian milled rice as price factors.

2.2 Trade Liberalization Policies and Rice Production

Before 1990, Nepal had direct governance from the Kingdom that provided no open access to the outside market. With the political revolution in 1990, a multi-party democracy was re-stored, and the open-market and trade liberalization policies were adopted (Ojha, 2008). These policies were the supportive steps taken for Nepal to be a member of the WTO, and it was highly motivated to be gained from the lower cost and higher quality of goods as well as the potential benefits of country's comparative advantage of global trade. Import tariff reduction is a critical piece of the trade liberalization policies, and it is strongly advocated and mandated by the International Monetary Fund and the World Bank during the course of negotiating loan packages with developing countries. Accordingly, the government of Nepal has also cut import tariffs on rice dramatically from 35 percent to the current level of 3 percent (Cockburn, 2002). Rice production, following the adoption of these policies, dropped dramatically and its import increased. The flooding of cheap rice mainly from India has exerted a negative impact on rice production in Nepal (Pyakuryal et al., 2005).

Furthermore, rice production in India has been subsidized by the Indian government through a variety of measures (Papademetriou, 2000) but the Nepalese farmers receive no such support. Thus, the competition between Nepalese and Indian rice growers is quite unfair. Before the intervention of the trade liberalization policies, the advocates supposed that lowering rice tariffs would benefit the Nepalese society but Cockburn (2002) reported that although consumers in urban areas are better off because of lower retail price resulting from the lower tariffs, it was counterproductive to the poor farmers and their livelihood. Nath (2004) also reported that the domestic price was heavily influenced by the price of the Indian rice due to the Nepal-India Treaty of Trade negotiation in 1996. The treaty allows the trade of primary agricultural products between the two countries to be minimum customs duties and free of quantity restrictions. Jull (2006) mentioned that Nepal relies on the import of cheap food from India. Before the Marrakech Decision for Nepal's accession in the WTO, it was not listed as a net-food importing country, but now it is. According to MOAC (2009), about 90 percent of imported rice comes from India. In summary, it is inferred that

Nepal is highly dependent on the Indian market for agricultural trade. According to Karmacharya (2008), price transmission for rice, wheat and maize from India to domestic markets after policies intervention was lower in the rural areas and mountains as compared to the Terai belt because of the poor transportation and communication infrastructure, and this might be the reason for Cockburn's findings.

During the time, many people have been engaged in the debate of trade liberalization policies, and are coming up with different conclusions. Georges (2004) argued the negative effect of trade policies on rice supply in Haiti, while Huq and Arshad (2010) reported a positive effect on potato supply in Bangladesh. In this context, this study is also set to investigate the behavioral response of rice supply resulting from the trade liberalization policies.

3. Methodological Framework

3.1 Theoretical Model

Nepalese farmers are both producers and consumers of the same agricultural products and they are likely to take decisions on production and consumption simultaneously. They generally have access to only the local markets where they sell surplus products to purchase non-farm commodities and they make recursive decisions (Carter *et al.*, 1999). According to the recursive decision model, the farm household first maximizes profits as a producer that will maximize household income and then allocates its income to maximize utility as consumers. Individually, rice farmers don't have any influencing power to distort the market price. Rational farmers maximize the profit subject to their production function, inputs availability and exogenous prices. Mathematically, it is written as

$$\max_{z,y} \quad \pi(p, w; z) \quad st \quad f(z) \geq y \tag{1}$$

where, $\pi(p, w; z)$, *f(z)*, p and w, respectively, represent restricted profit, production function, and output and input prices, while z represents quantities of factors of production.

The optimization of the profit function gives the profit maximizing level of output supply, $y^*(p)$ and this is also identical to the Hotelling's Lemma. Mathematically, it is written as

$$y^*(p) = \partial\pi(p)/\partial p \qquad (2)$$

Equation (2) gives an optimal output supply function of rice, and it holds $y^*(p) \geq y(p)$ because the maximization problem follows the first-order condition, $\partial y(p)/\partial p = \partial^2\pi/\partial p \geq 0$. Price elasticity of supply function is an important concept to analyse the responsiveness of quantity supplied as price changes. Economic theory suggests that price elasticity of supply gives a single measure of sensitivity of quantity supplied with price changes at a particular point of supply curve (at a particular time in the time series analysis).

In this study, we are going to specify a rice supply model based on time series data of the prices of rice in both Nepalese and Indian markets, and the supply of improved seed, and also estimate supply responsiveness with respect to the aforementioned variables.

3.2 Error Correction Model

Error correction model (ECM) is developed to explain the long-run effect of explanatory variables on the dependent variable. For the analysis, it begins with a consideration of a simple model as

$$y_t = m + \alpha y_{t-1} + \beta_i x_{i,t} + \gamma_i x_{i,t-1} + e_t, \qquad (3)$$

where,
y is the dependent variable - rice supply,
x is the vector of explanatory variables and it includes the prices of Nepalese and Indian rice, and the supply of improved seeds.
e_t is the disturbance term, and
β's are the coefficients of respective variables.

Equation (3) describes the dynamic effects of a change in x_t upon current and future values of y_t.

Equation (3) can also be written as

$$y_t = \frac{1}{(1-\alpha L)}\left[m + (\beta + \gamma L)x_t + e_t\right] \tag{4}$$

where, L is the lagged operator.

Co-integration and error-correction techniques are applied for the analysis of agricultural supply response as done by a number of researchers, such as Hallam and Zanoli (1993), Townsend (1997), Thiele (2002), Piya (2009), Huq and Ashram (2010), and others. One major use of the co-integration technique is to establish long-run equilibrium relationships between the variables. If the variables are integrated of order one, I (1), and the error term I (0), it implies that any drift between variables in the short-run is temporary and that the equilibrium holds in the long-run.

In the long-run, it can be assumed that y reaches a new level of equilibrium associated with the new level of x, and it continues to exist until there is a new shock to the system. Variables do not change from one time period to the next. While mathematically speaking $e_t = \bar{e} = 0$, because of no shocks; and suppose $\bar{y} = y_t = y_{t-1}$ at equilibrium because of the invariant nature of the variables. This implies that the lagged operator, L, is equal to one. Thus, equation (4) becomes

$$\bar{y} = \frac{1}{(1-\alpha)}\left[m + (\beta + \gamma)\bar{x}\right] \tag{5}$$

Equation (5) reveals the long-run equilibrium relationship between x and y, and the long-run impact of x on y is now $\partial\bar{y}/\partial\bar{x} = (\beta+\gamma)/(1-\alpha)$, whereas the short-run response is $\partial y/\partial x_i = \beta_i$. The short-run response (β_i) gives the immediate impact multiplier of a unit increase in x on y, while the long-run impact multiplier gives an expected cumulative increase in y as x

increases by one unit. These impact multipliers evaluate the tendency of a proportionate change in y_t with respect to x_t, and thus, they are also characterized as short-run and long-run elasticities as well.

By setting $y_t = y_{t-1} + \Delta y_t$, and $x_t = x_{t-1} + \Delta x_t$, we can re-write equation (3) as

$$\Delta y_t = \beta_i \Delta x_{i,t} - (1-\alpha)\left[y_{t-1} - \frac{m}{1-\alpha} - \frac{\beta_i + \gamma}{1-\alpha} x_{i,t-1} \right] + e_t \qquad (6)$$

When the variables x and y hold a long-run equilibrium, the term in square brackets on the right hand side of equation (6) would be zero. When the content of the square bracket is positive, y_{t-1} is above its equilibrium. Thus this term pulls y back down towards equilibrium in the next time period. Similarly, when the content is negative, it pulls y up towards equilibrium in the next period. Thus this term, also known as "error correction term", gives an adjustment of the variables around the equilibrium point and the coefficient *(1-α)* is the adjustment coefficient. The higher the coefficient, *i.e.*, the smaller α, the faster is the speed of adjustment.

Furthermore, the implication of trade liberalization policies also brings an effect on agricultural supply as being discussed in previous section 2.2. Thus, the intervention of these policies is also considered in the model with a dummy variable; and for the purpose, a value of 0 is assigned for the years before 1990, and 1 in otherwise cases in order to visualize its effect on the supply behaviour.

3.3 Empirical Methodology

3.3.1 Model

In this section, an empirical model is identified to capture a dynamic relationship where the explanatory variables work their way through to the dependent variable in stages and give non-contemporaneous relationships. Supply response of agricultural commodities depends on both price and non-price factors as we discussed in section 2.1. A change in input prices affects the cost of production while the output price affects farmers' profit incentives to produce more, but the observed prices are only known after the production has occurred. Thus, the price expectations play a key role in the analysis. In this case, the actual price in the previous period is considered as the producers' expected price since farmers especially in the developing countries are mostly less literate and it is difficult for them to have a closure prediction. In addition to the price factor, there are several non-price factors that affect the supply response of agricultural commodities.

It is not convenient to incorporate all the factors due to the non-availability of data especially on the non-price factors such as irrigation, fertilizer consumption, road networks and the use of machinery. Considering these drawbacks, supply response model is estimated using the variables mentioned in equation (7) below:

$$\Delta SUP_t = m + \beta_1 \Delta NPR_{i,t-1} + \beta_2 \Delta IPR_{i,t-1} + \beta_2 \Delta SED_{i,t} + (\alpha - 1) SUP_{t-1}$$
$$+ (\beta_i + \gamma_i) NPR_{t-1} + IPR_{t-1} + SED_t + IPR_{t-1} * DUMMY_t + V_{t-1} \quad (7)$$

where,

SUP_t	Rice Supply at time *t* in logarithms
SED_t	Supply of improve seed of rice at time *t*
NPR_{t-1}	Price of Nepalese rice at one lagged of time *t*
IPR_{t-1}	Price of Indian rice at one lagged of time *t*
$DUMMY_t$	Dummy for the adoption of trade liberalization policies in 1990
V_{t-1}	Error correction term

Along with the empirical model, it is also important to discuss on specifying the use of functional form in the model since some literature have used linear model while the others have done with log-linear form. Muchapondwa (2008), Tripathi (2008) and Piya (2009) went for the use of a linear functional form of time series regression. However, McKay *et. al* (1999), Thiele (2000), and Huq and Arshad (2010) worked with the log-linear functional form to estimate the supply response. To avoid the scepticism on specifying the functional form, the PE test propounded by

MacKinnon, White and Davidson in 1983, was suggested for identifying an appropriate functional form that avoids the dilemma above (Verbeek, 2008).

In the PE test, the linear model was tested against its log-linear alternative model and the null hypothesis of $\delta_{lin} = 0$ was tested.

$$SUP_t = \beta_1 SED_t + \beta_2 NPR_{t-1} + \beta_3 IPR_{t-1} + \beta_4 (DUMMY_t * IPR_{t-1}) + \delta_{lin} (\ln \hat{SUP}_t - \ln \tilde{SUP}_t) + e_t \quad (8)$$

Where, $\ln S\hat{U}P$ is the logarithmic form of predicted values of linear regression model, and $\ln S\tilde{U}P$ is the predicted value of the log-linear regression model.

Similarly, the null hypothesis of $\delta_{\ln} = 0$ was tested in the log-linear model.

$$\ln SUP_t = \beta_1 \ln SED_t + \beta_2 \ln NPR_{t-1} + \beta_3 \ln IPR_{t-1} + \beta_4 \ln(DUMMY_t * IPR_{t-1}) + \delta_{\ln} (\hat{SUP}_t - \exp(\ln \tilde{SUP}_t)) + e_t \quad (8a)$$

where, δ_{lin} and , $\delta_{\ln}$ are the coefficients of respective variables.

In the above models, if , $\delta_{lin} = 0$ is not rejected, the linear model may be preferred. If $\delta_{\ln} = 0$ is not rejected, the log-linear model is preferred.

3.3.2 Integration and Co-integration

In time series regression, the data need to be stationary in order for the usual econometric analysis with proper statistical properties. Otherwise, the regression among non-stationary series results in a spurious regression. Augmented Dickey-Fuller (ADF) test was used to investigate the presence of non-stationary data in the data series. Differencing is the most common transformation which may be a useful tool to correct the problem. Once the data series were found stationary, a co-integration test was carried out to observe whether the variables under consideration have a long-run relationship. For this test, the Engle-Granger Two-Step method as suggested by Adkins and Hill (2007) was applied. Since the OLS residual was used for this test, the critical values as given in Stata table are not appropriate and hence, suggested to check with the MacKinnon critical values (Verbeek, 2008). With the correct critical values, the Engle-Granger method was used to test the null hypothesis of non-stationary residuals. In other words, it was tested to examine whether or not the variables have a long-run relationship.

3.3.3 Data Requirement and Specification of Time Period

The data on rice supply, prices in both Nepalese and Indian markets, and the supply of improved seed were collected from the FAO database for the period of 1966 to 2007. The data on rice supply was considered as a dependent variable expressing the unit in thousand metric tons, whereas the explanatory variables, the supply of improved seed in the unit of tones and the output prices on Nepalese and Indian markets were considered in their own local currency. For the analysis the effect of two prices measured in different currencies, the Indian price was converted into the Nepalese currency to maintain similarity in the price unit, and the exchange rate between these currencies follows the pegged exchange system since few decades back, that is, IRs. 1.00 is equivalent to NRs. 1.60.

To facilitate proper understanding on supply behavior of rice, the entire period of 42 years is divided into two sub-periods on the basis of political breakthrough made in 1990 in Nepal and they are - pre-globalization (1966 to 1989) and post-globalization period (1990 to 2007). During the pre-globalization period, it was hypothesized that the country had experienced the slow growth of agricultural development in a closed economy. During this period, the open-market and trade liberalization policies were not practiced, but after restoration of the multiparty democracy in 1990, policies were introduced to bring technological transformation into agriculture production. Thus, it was hypothesized that most of the efforts that were invested to bring technology-driven agricultural production were opened during the post-globalization period.

4. Results

4.1 Specification of Functional Form

For the analysis of supply response on price, the supply structure of Nepalese rice was investigated, but the issue of specification of the functional form was rather important. It was argued that the log-linear functional form has an advantage of having constant elasticities of parameter estimates, and the reduction of heteroskedasticity as well as the impact of influential observations. The result of the PE test is presented in Table 1, where *y* indicates the dependent variable, that is, rice supply.

Table 1
The PE Test for Specification of Functional Form

Variables	Coefficient	
	Linear Model	Log-linear Model
SED_t	33.74***	1.09***
NPR_{t-1}	0.09***	0.25***
IPR_{t-1}	0.03*	0.11**
$DUMMY*IPR_{t-1}$	-0.03***	-0.01***
$(\ln S\hat{U}P - \ln S\tilde{U}P)$	-1139.72*	-
$(S\hat{U}P - \exp(\ln S\tilde{U}P))$	-	0.0002
Constant	-1416.94***	-0.25
F-value	337.85***	271.37***
R-Square	0.98	0.98

Note: ***significant at 1% level, **significant at 5% level, *significant at 10% level

Rejection of null hypothesis of the coefficient of variable, $(\ln S\hat{U}P - \ln S\tilde{U}P)$ in linear regression suggested going for the use of log-linear model. It was also supported by the non-significance of the coefficient of variable, $(S\hat{U}P - \exp(\ln S\tilde{U}P))$ in the log-linear model. Thus, the above statistical test signaled better suitability of the log-linear model over the linear one for the further analysis. However, the choice of functional form sometimes is also based on what researcher needs the model for.

4.2 Integration and Co-integration

The test for the order of integration is a step before co-integration analysis. An integrated series is originally non-stationary and gives an accumulation of past effects, that is, perturbation to the series does not return to any particular mean value (Tripathi, 2008). The number of times of differencing before the variable is actually made stationary and determines the order of integration.

The ADF test was carried out to identify the nature of the data series. It was important to identify an appropriate number of lagged terms to explain the dynamic behavior of the time series variables. Adkins and Hill (2007) suggested starting the test with enough lags to eliminate autocorrelation in the residuals and observe the significance of the last lagged coefficient. If it is non-significant, we eliminate it from the model and repeat the same procedure until the last lag becomes significant at the 10 percent level. It was assumed that a significant lag coefficient provides a meaningful outcome of including lagged values. In our study, the ADF test was started with three lags and looked on significance of the last lagged coefficient as suggested by Adkins and Hill (2007). However, only the first-lagged coefficient was found to be significant with a constant but no trend except in case of variables, usage of improved seed. NYU (2009) also suggested working with lagged-one values in case of annual data series. Furthermore, a test on lag length criteria was also conducted to select the appropriate lag order and the result is presented as follows in Table 2.

Table 2
Lag Order Selection

Lag	LogL	LR	FPE	AIC	SC	HQ
0	141.1645	NA	1.27e-08	-6.828950	-6.487707	-6.706515
1	241.9387	170.5409*	1.66e-10*	-11.17634*	-10.15261*	-10.80904*
2	253.6301	17.38726	2.15e-10	-10.95539	-9.249174	-10.34321
3	268.7984	19.44645	2.45e-10	-10.91274	-8.524032	-10.05569

* indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5% level), FPE: Final prediction error, AIC: Akaike information criterion, SC: Schwarz information criterion, HQ: Hannan-Quinn information criterion

The lag order selection criteria such as Akaike information criterion (AIC), Schwarz information criterion (SC) and Hannan-Quinn information criterion (HQ) as well suggested considering only one lag order. In this way, the study came up with a conclusion of considering the autoregressive distributed lag models with lag order one, that is, ADL (1,1).

Table 3 reports the ADF test results of the logarithmic series with a trend and a constant.

Table 3
Results of the ADF Unit Root Test

Variable level	ADF Statistic	P-value	First differenced	ADF Statistic	P-Value
$lnSUP_t$	-2.15	0.52	$\Delta lnSUP_t$	-5.79	0.00
$lnSED_t$	-1.33	0.88	$\Delta lnSED_t$	-6.20	0.00
$lnNPR_{t-1}$	-1.84	0.69	$\Delta lnNPR_{t-1}$	-5.07	0.00
$lnIPR_{t-1}$	-2.53	0.31	$\Delta lnIPR_{t-1}$	-4.99	0.00

Note: Δ indicates change in; ***, ** and * significant at the 1%, 5% and 10% level, respectively.

Table 3 shows that the test statistics of all the variables do not fall within the rejection region and concludes that the levels of the data are non-stationary. The ADF tests were repeated for the differenced series. The differenced series had a drift term but no trend. In this case, we reject the non-stationary null hypothesis and conclude that all the series are stationary in their differences. Thus, all the data series are integrations of order 1. However, it is yet to investigate the co-integrating relationship among the variables before going for establishing the dynamic relationship among them. The variables are co-integrated if the non-stationary series move together through time. But still there is a doubt of spurious regression between those data series (Hill, Griffiths, & Lim, 2007); so a formal statistical test was carried out for co-integration. The Engle-Granger Two-Step Method was used to test the non-stationarity of residuals obtained from the OLS, and it was found that the null hypothesis of no co-integration is rejected at the 1 percent level of significance (See Annex I). In another words, the variables are co-integrated revealing a single long-run relationship among them. The above method confirmed that a non-spurious long-run equilibrium relationship exists, that is, $\ln Y_t = \alpha + \beta \cdot \ln X + e_t$, where X is a vector of explanatory variables, and e_t is I(0). However, there may be more than one cointegrating vector and so did the Johansen-Juselius cointegration rank test (also called the trace test) with the VAR(1). The result in Table 4 indicates the presence of just one cointegrating vector, and thus assuming one-way causality, the structural form of the ADL(1,1) is estimated with an error correction model.

Table 4
Johansen-Juselius Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.390817	48.35311	47.85613	0.0449
At most 1	0.316259	28.03198	29.79707	0.0788
At most 2	0.258006	12.44478	15.49471	0.1368
At most 3	0.005104	0.209792	3.841466	0.6469

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
*denotes rejection of the hypothesis at the 0.05 level, **MacKinnon-Haug-Michelis(1999)p-value

4.3 Error Correction Model

For the confirmation of the long-run relationship between the variables, the Error Correction Model (ECM) was developed. The ECM analyzed the relationship between the variables with I (1) and gives consistent estimates of both short-run and long-run elasticities. It can also be observed that the model fits the observed data fairly well and significant as indicated by the R-square and adjusted R-square in both short-run and long-run. The result of the ECM is presented in Table 5.

The ECM result shows that rice supply depends on the fluctuation in the supply of improved seed and the prices. The short-run supply positively responds to the supply of improved seed, and the coefficients are statistically significant at the 1 percent level. In case of the price factors, there are statistically significant supply responses in the short-run time horizon but they have a negative impact. However, in the long-run, both the Nepalese and Indian prices have positively impacted on the supply of rice in Nepal and are statistically significant.

Table 5
Error Correction Model

Variables	Short-run	Long-run	
Constant	-	-	-1.31
$Vhat_{t-1}$	-0.98**	$lnSUP_{t-1}$	-1.25***
$\Delta lnSED_t$	0.90***	$lnSED_{t-1}$	1.65***
$\Delta lnNPR_{t-1}$	-0.23**	$lnNPR_{t-1}$	0.29***
$\Delta lnIPR_{t-1}$	-0.17***	$lnIPR_{t-1}$	0.13***
ln(DUMMY*IPR_{t-1}	-	-	-0.02**
R-Square	0.56	-	-
F-statistic	4.13***	-	-

Note: ***significant at 1% level, **significant at 5% level, *significant at 10% level

In this study, the supply of improved varieties is considered as a proxy of technology since technological advancement allows increased supply of improved and high yielding varieties. Rice supply positively responded to the supply of improved seeds both in the short-run and long-run conditions. The error-correction term, also coined as "adjustment coefficient" measures the speed of adjustment towards the long-run equilibrium. It carries the expected negative sign with a value of 0.98 and statistically significant at the 5 percent level of significance. The coefficient indicates that a feedback of 98 percent of the deviation of rice supply from its long-run equilibrium level is corrected each year. In other words, it explains that the dis-equilibrium in short-run supply quickly moved to the long-run steady state level. Nepalese farming being subsistence oriented and having no close substitute of rice cultivation during the monsoon season, the farmers go for rice farming in any case and quickly response to shocks in the long-run equilibrium. This response behavior in relation to the adjustment in dis-equilibrium is captured by the coefficient of error correction term and it is close to the findings of Piya (2009).

The interaction variable controls for the impact of Indian price on rice supply between the pre- and post- globalization periods. The coefficient of interaction variable is negative and statistically significant at the 1 percent level of significance. This result tells that the Indian price has negative effect for the post-globalization period than it does for the pre-globalization period. In another words, it reveals that the Indian price has the differential effect on rice supply for the pre- and post-globalization period. This result shows the negative impact of the Indian price on rice supply in Nepal after the introduction of open-market and trade liberalization policies.

4.4 Short-run and Long-run Elasticities

The coefficients of the ECM model give the short-run elasticities, while the long-run elasticities are obtained from the coefficients of equation (7). The elasticities for both short-run and long-run are given in Table 6.

Table 6
Short-run and Long-run Supply Elasticities

Variables	Short-run	Long-run
Nepalese Price	-0.23**	0.29***
Indian Price	-0.17***	0.13***
Seed supply	0.90***	1.65***

Note: ***significant at 1% level, **significant at 5% level, *significant at 10% level

From Table 6, it is revealed that the absolute values of elasticities of the price factors are very low as compared to those of the non-price factors. Similar results were suggested by Martin *et al.*, (1993), Muchapondwa (2008), Tripathi (2008) and Thiele (2000) for developing and least developed countries. As rice being the basic food of 27.5 million Nepalese people, the subsistence farmers are less responsive to the changes in market prices. On the other hand, it also confirms that the non-price factor – supply of improved seed is relatively more important for rice supply.

Also, Nepalese farmers are less concerned about maximizing their profits since more than 70 percent of the households are small land holders and subsistence-oriented. Thus, subsistence farming might be one of the causes of the low supply response to price. Furthermore, rice supply responsiveness is higher and quicker for the non-price factor, rather than the price factors. It reflects a potential scope of improving the level of non-price factor to increase agricultural supply. The non-price factors are the main bottlenecks for agricultural development in developing and least developed countries like Nepal, and farmers are less likely to stay in farming (Tripathi, 2008). According to NSSO (2005), about 40 percent farmers do not like to stay in farming but they have no alternative(s). This might be the other reason for the low supply response of farmers and higher elasticities for non-price factors in Nepal.

5. Conclusion and Discussion

The impact of fluctuations of both Nepalese and Indian prices on supply is statistically significant in the short-run and long-run time frames. The responses of the prices in the short-run are negative, while the long-run impacts are found to be positive. The short-run supply responses to the Nepalese and Indian prices are 0.23 and 0.17, respectively while they are 0.29 and 0.13 in case of long-run. The short-run negative elasticity of the price looks unusual but it can be explained in the case of Nepal. Agriculture is the mainstay of Nepalese farmers around which the economic activities revolve. As market shows the symptom of decreasing price, farmers may feel financially unsecure and start supplying their rice for sale since they cannot hold the stock for a long time. As the long-run impact of Indian price is positive, the government should focus on controlling cheap imports from India for increasing the supply of rice. Moreover, the government should also think about establishing a long-run price stability that enhances long-run investment in agriculture since the short-run impact of price is not encouraging for supply.

Rice is the staple crop of Nepal and produced in more subsistence environment in the rural areas. This could be the reason for the higher elasticities for the supply of improved seed. Furthermore, the low price response of rice supply might be due to poor market linkage and inadequate development of agro-industry in Nepal. Looking into the higher supply response of the seed supply, government policy should be directed towards increasing the supply of improved seed.

Further research can focus on identifying the factors that determines supply of rice and estimating the supply responsiveness with respect to the Nepal's accession in the WTO. In Nepal, small and marginal farmers, on one hand, are compelled to sell their products at a given price while on the other hand, the medium and large-scale farmers are practicing cartel of rice supply to secure higher price during the off-period(s). Thus identifying the factors that determine the supply behavior will help to stimulate the farmers to increase production and supply. Furthermore, the study of rice supply under general equilibrium condition will help to identify the causes and impact multipliers of rice supply.

This study is based on secondary data collected and published by the various agencies of the government of Nepal and the FAO database. The data being collected during the democracy period are supposed to be more reliable as compared to the data relating to the Panchyat Period. The realism of this assumption is based on the fact that several improvements and refinements have been made in the method of collection of statistical data during the democracy period. The data in some variables are available only for the democracy period because a systematic way of data collection, record-keeping and their publication was started from the year 1990-91. This reveals part of the limitations of this research since it was not possible to consider enough variables of the non-price factors. The scope of investigation, therefore, limits itself to study the aspects mentioned in objectives. However, an attempt is made to have an in-depth analysis of the data to accomplish the objectives with meaningful conclusions.

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Annexure

Annexure I

An output of the Engle-Granger test of co-integration

Variable	$\Delta ehat_t$
L1.ehat	- 0.44*** (0.13)
R-square	0.2218
F-statistic	10.83
P-value	0.002

Note: Δ indicates the same as in Table 2. Parenthesis indicates the standard error.
$ehat_t$ is the predicted residuals of regression $lnSupply_t$ on L1.lnNEPRICE, L1.lnINPRICE, $lnSEED_t$ and $lnINTERAC_t$.