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Supply Response of Potato in Bangladesh: A Vector Error Correction Approach

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Abstract: An attempt has been made in this study to examine the supply response of potato in Bangladesh by using the vector error correction approach. The short-run price elasticity was 0.45 while the long run elasticity was 0.62. Price policies are effective in obtaining the desired level of output for potato. If intervention in the market is of necessity, then it must be implemented during the harvest season for altering price expectations. Also emphases should be given to increase potato export and establishing export oriented potato processing industries.

Key words: Supply response, potato, vector error correction approach

INTRODUCTION

Bangladesh-the mostly densely populated country in South Asia produces substantial quantity of potato. This happens to be one of the most important vegetables as well as cash crop of the country. Almost every family in Bangladesh consumes potato as a vegetable round the year. As a cheapest source of carbohydrates it is used, not so extensively, as a supplement of our main diet-rice. A little change in the dietary pattern through inclusion of potato in day-to-day meal would reduce our dependency on rice and thereby the country can save foreign currency. In this connection, a promotional effort has been taken by the government for increasing consumption of potato after rice and wheat. Potato is grown during winter season for which it is less susceptible to the monsoon rains and floods (Afsar, 1997). Bangladeshi potato has entered into the world market since 1997-98. Potato is also the leading vegetable crop in the world and at present people of at least 40 countries eats potato as their staple food (Islam, 1987).

Area under potato (301.2 thousand hectares) covered 3.57% of cultivable land (8,440 thousand hectares). It covered 4% area of total crop grown in rabi season. The average national yield of potato is quite low (Table 1). As a vegetable crop, potato area is more than the total area of all other winter vegetables in Bangladesh (BBS, 2008). Potato is entering into export trade from 1997-98 for Bangladesh and in the middle of 1990's decade 3 to 4 export oriented potato flakes industries are established in different parts of Bangladesh. To meet the extra demand of potato supply also shift upward, as a result

Table 1: Area and Production of potato in Bangladesh

Year	Area ('000' ha)	Production ('000' tons)	Yield (t ha^{-1})
1980-81	102.0	963.0	9.44
1981-82	107.6	1035.0	9.62
1982-83	110.1	1149.0	10.44
1983-84	110.1	1166.0	10.59
1984-85	111.3	1159.0	10.41
1985-86	108.4	1102.0	10.17
1986-87	108.4	1069.0	9.86
1987-88	123.4	1276.0	10.34
1988-89	111.3	1089.0	9.78
1989-90	116.5	1066.0	9.15
1990-91	123.8	1237.0	9.99
1991-92	127.9	1379.0	10.78
1992-93	126.6	1384.0	10.93
1993-94	131.2	1438.1	10.96
1994-95	131.5	1468.0	11.16
1995-96	132.3	1492.0	11.28
1996-97	134.0	1508.0	11.25
1997-98	136.3	1553.1	11.39
1998-99	244.9	2761.9	11.28
1999-00	243.3	2933.0	12.06
2000-01	249.0	3216.0	12.92
2001-02	237.6	2994.0	12.60
2002-03	245.3	3385.9	13.80
2003-04	270.9	3907.1	14.42
2004-05	326.3	4856.0	14.88
2005-06	301.2	6150.0	20.42

Source: Bangladesh Bureau of Statistics (BBS)

from 1998-99 area and production suddenly increase much higher than previous trend.

Supply response is used as a tool to evaluate the effectiveness of price policies in the allocation of farmer's resource and estimates of supply responsiveness provides useful guidelines to the formulation of economic policy. The price policies have long formed the basis of farm decisions in majority of the least developing countries. It provides a framework for adjusting

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production for optimum resource employment with the objective of promoting economic development. According to Nerlove and Bachnan (1960), research on supply response is to improve the understanding of the price mechanism. Besides prices, there are various other non-price factors such as weather, irrigation, technology etc that also influence supply. The knowledge of supply response greatly helps in farm decisions in the allocation of resources in right direction. It can help planners and policy makers to allocate and achieve productions targets and in long term planning. The supply response equations can be used to forecast the agricultural supplies in the future. This requires regular agricultural supply response analysis periodically for improving the reliability of supply parameters, which are the foundations of agricultural policy. Therefore, a thorough knowledge of the supply response of food and the implications of policies will be useful for planning food production and the all round development of the country.

In Bangladesh, considerable numbers of research studies were done on potato, which centred on estimation of production cost, gross return, gross margin and resource use efficiency. Very few studies have been conducted on market which were mostly inadequate and reflected very past situation. Some of the researchers tried to examine the responsiveness of farmers in allocating land for potato cultivation by fitting Nerlovian type area response model.

Sabur (1983) formulated equations for area response to price of potato were estimated using time series data (1960-61 to 1981-82), within the Nerlovian dynamic models framework, which included lagged values of the dependent variable on the right hand side of the estimating equation, the error terms of the estimated equations were postulated to be in auto-regressive structure. The combination of lagged dependent variable and as auto correlated disturbance renders OLS inconsistent. The OLS should not be used in such a case (Johnston and DiNardo, 1997). Huq et al. (2007) also used Nerlovian Area (Partial) Adjustment Model for supply response estimation for potato. In recent years, cointegration analysis is being widely adopted by different economists for estimation purpose of supply response (Ocran and Biekpe, 2008; Mohammad et al., 2007; Edet et al., 2007; Brescia and Lema, 2007; Elbeydi et al., 2007; Thiele, 2003; Muchapondwa, 2008). Research work did in Bangladesh rarely used co integration analysis however this is a powerful tool to analyse time series data. And usage of this tool is being utilised for this study.

The present study is an attempt to estimate the long run and short run supply elasticities of potato in Bangladesh.

MATERIALS AND METHODS

Sources of data: The time series data for the period 1982-83 to 2005-06 taken from Bangladesh Bureau of Statistics (BBS, 1987, 1993, 1995, 1998, 2008) were utilised for this study, because agricultural sector prior to the eighties were highly subsidized by the Government. Withdrawal of subsidies and handing over fertilizer and irrigation equipment marketing to private sector started from the eighties. Simultaneously open market economy and privatisation policy also began from the same period. Considering all of these, this period was considered appropriate. Present Government is also again given subsidy on fertilizer and irrigation.

Data on area, production and productivity (Yield/hectare) of potato were collected from The Yearbook of Agricultural Statistics published by the Bureau of Statistics, Ministry of Planning and Government of the People's Republic of Bangladesh.

Analytical framework: Since the appearance of Nerlove's work 55 years ago, most studies on agricultural supply response have relied on dynamic econometric supply functions estimated directly from time series data. Nerlove (1958) model captures the dynamics of agriculture by incorporating price expectations and/or adjustment costs. This model can be extended to include other expectation variables other than price to capture imperfect information on these variables. In the Nerlove price expectations model, the desired output is a function of price expectations P_t^e so that the supply function can be represented as:

$$X_t^* = a + bP_t^e$$

where, b is the long-run elasticity of output with respect to price. Assuming that price expectations are adaptive then:

$$P_t^e - P_{t-1}^e = \delta(P_{t-1} - P_{t-1}^e)$$

The Nerlove (1979) partial adjustment model assumes that in each period, a proportion of the difference between current output and long-run desired output is correlated. However, the framework fails to accommodate the full dynamics of supply, thereby underestimating elasticity of supply or biasing it downwards (Nickel, 1995; Thiele, 2000).

In an alternative procedure, Griliches (1959) used input demand elasticity in estimating agriculture supply response with the aid of a constant return-Cobb-Douglas production function. Until now the Griliches approach has

been used only for developed countries, mostly because of its exacting demands in terms of data requirement on inputs and output prices. The absence of extensive data on agricultural input and outputs for low-income countries makes the Griliches approach unsuitable for work in Bangladesh.

Recent work has recast the supply response model in error correction form, with the partial adjustment model nesting within it and with a stronger theoretical basis (Hallam and Zanoli, 1993). Several study uses cointegration analysis, which only requires a co-movement of agricultural supply and price in the long-run. The most widely known single equation approach to co-integration is the Engle-Granger two-step procedure. This approach has some limitations. Firstly it ignores short-run dynamics when estimating the cointegrating vector. When short-run dynamics are complex, this biases the estimate of the long-run relationship in finite samples.

To counter this, a test based on the coefficient of the lagged dependent variable in an autoregressive distributed lag framework has been proposed by Banerjee *et al.* (1998). However, the parameter estimates are only asymptotically efficient on the assumption of weak erogeneity of the repressors. McKay *et al.* (1999) adopts this approach but there is reason to believe that agricultural prices may not be weakly exogenous thus shading doubt on the asymptotic efficiency and consequently validity of their estimates. Secondly, the procedure only assumes that one cointegrating vector exists leading to inefficiency in estimation if there is more than one cointegrating vector. The Johansen estimation procedure deals with this problem but like the Engle-Granger procedure, it presupposes that the order of integration of the all variables is the same and known with certainty. However, the power of unit root test is low hence it can never be known with certainty whether the postulated order of integration is correct.

The relatively recent Autoregressive Distributed Lag (ARDL) approach to cointegration proposed by Pesaran *et al.* (2001) overcomes some of these problems. Narayan (2005), however, argues that critical values generated by Pesaran *et al.* (2001) cannot be used in small samples since they are based on large samples. The major disadvantage of the ARDL approach to cointegration is that it is valid only in the case of a single cointegrating relation. In the event of more than one cointegration relation, ARDL estimation will not be valid.

Consequently, the present study uses the method of cointegration and its implied error correction model to overcome the problems usually encountered with the use of the traditional Nerlovian model. In specific terms, the Johansen's method of cointegration, which results in the Vector Error Correction Model (VECM), was used. The vector error correction model is an extension of the Vector Auto-Regression (VAR) model developed by Johansen and Juselius (1990) and Johansen (1991).

Specification of models: We specify a model relating to potato area (LnAt) to real potato price (LnPt), yield of potato (LnY), dummy variable (D01), as well as coefficient of variation of price (CV of P_t) and coefficient of variation of yield (CV of Y_t) of potato over the preceding two years, used as proxy for risk.

In this study, the area planted is used in lieu of planned output, which may be justified by the fact that the farmers have greater control over the area than on the production or output. In this case, we assume that other inputs are varied in proportion to land and that constant returns to scale prevail.

Harvest price of potato is taken in this model because most of the farmers in Bangladesh dispose off their products just after the harvest. To arrive at a deflated price, per tonne harvest price of potato is divided by wholesale harvest price of boro paddy (competing crop) to reflect output values in real terms.

Yield of crop concerned is a major supply shifter so far as it is representative of technological changes related with the crop. One year lagged yield is assumed to represent the expected yield in the next year. In resource allocation decision is based upon farmer's reaction in which case the immediate past yield may weigh heavily and hence last year's yield is considered adequate to represent expected yield.

Farmer's rational conduct, following the risk aversion hypothesis would imply that given the subjective price probability distributions, farmers would seek to maximise expected utility, i.e., the expected return which is a measure of the risk. Risk element is incorporated in the supply response equation by including coefficient of variation of price (CV of P_t) and coefficient of variation of yield (CV of Y_t) of potato over the preceding two years.

From the middle of 1990's potato is included in the export trade basket and 3 to 4 export oriented potato flakes industries were established in different parts of Bangladesh. To meet the extra demand of potato supply, there was a major upward shift from 1998-99 in the areas under production. For this reason a dummy variable include in the model, which takes value 0 before 1998-99 and take value 1 from 1998-99.

In this model, it is hypothesized that potato area and real potato price are jointly determined (that is endogenous to the system) while the other variables (as expected) is exogenous to the system. During

estimation non significant variable will exclude from the model when it found as irrelevant. Consequent upon this condition, we straightforwardly specify the following Vector Error Correction Model (VECM):

$$\Delta Zt = \delta + \Gamma_1 \Delta Z_{t-1} + \Gamma_2 \Delta Z_{t-2} + ... + \Gamma_{p-1} \Delta Z_{t-p-1} + \Pi Z_{t-p} + \psi X_t + U_t \quad (1)$$

where, Z_t = is a (nxl) vector of jointly determined non-stationary I (1) endogenous variables; such that $\Delta Z_t = Z_t - Z_{t-1}$. X_t is a (qxl) vector of stationary I (0) exogenous variables. δ is a (nxl) vector of parameters (intercepts). Π and Γ_i are (nxn) matrices of parameters. ψ is a (nxq) matrix of parameters. U_t is a (nxl) vector of random variables, distributed as empirical white noise. Γ_i is a (nxl) vector of coefficients of lagged Z_t variables. Π is a (nxl) long-run impact matrix. The Π matrix is a product of two nxl matrices α and β such that $\Pi_z = \alpha_z \beta$. α_z represents the speed of adjustment coefficient. β represents the unique nature of the co integration space.

From Eq. 1, $Z_t = [LnA_t, LnP_t]'$ and $X_t = [LnY_t, CVP_t, CVY_t, D01]'$, where all the variables are as previously defined.

In the above specification, the information about the short-run and long-run adjustments to the changes in Z_t can be obtained through the estimates of Γ_i and Π, respectively. The Π matrix in Eq. 1, which is termed the long-run impact matrix of the error correction mechanism, is of primary importance. First the rank of Π provides the basis for determining the existence of co integration or long-run relationship between variables. There are three possibilities with regard to the rank of Π.

If rank (Π) is zero, then the variables are not co integrated and the model is equivalent to a VAR model in first differences; if 0<rank (Π)<n, then the variables are co integrated and if the rank (Π) = n, then the variables are stationary and the model is equivalent to a VAR model in levels.

Second, since the term ΠZ_{t-k} provides information about the long-run equilibrium relationship (co integrating relationship) between the variables in Z_t, the Π matrix can be decomposed into the product of matrices α and β, that is, $\Pi = \alpha\beta$. Where α is the matrix of speed of adjustment coefficients which characterises the long-run dynamics of the system, while β is the matrix representing the co integrating relations in which βZ_t (the disequilibrium error) is stationary (Johansen and Juselius, 1990; Chang and Griffith, 1998). A large value of a means that the system will respond to a deviation from long-run equilibrium very quickly (that is, with a rapid adjustment) and vice versa.

Given the above vector error correction model in Eq. 1, the long-run co integrating equation for potato output can be written as:

$$LnAt = \phi_0 + \phi_1 LnP_t + e_t \quad (2)$$

where, ϕ_0 is a constant intercept term; ϕ_1 is the long-run static coefficients and e_t is the random term with the usual stochastic assumptions.

The study adopts the Johansen Maximum Likelihood procedure of co integration. In this method, a preliminary analysis is carried out first to assess the order of integration of the data series through the use of unit root tests after which we test for the existence of co integrating (long-run equilibrium) relationships among the data series. If a valid co integrating relationship is found, then we estimate a vector error correction model, since co integration is a pre-condition for the estimation of an error correction model.

Test for unit roots: To carry out the unit root test for stationary, the study uses the Augmented Dickey-Fuller (ADF) test to examine each of the variables for the presence of a unit root (an indication of non-stationary), since it can handle both first order as well as higher order auto-regressive processes, by including the first difference in lags in the test in such a way that the error term is distributed as white noise. The test formula for the ADF is shown in Eq. 3:

$$\Delta Y_t = \alpha + \rho Y_{t-1} + \sum_{t-1}^{j} \gamma \Delta Y_{t-1} + \mu_t \quad (3)$$

where, Y is the series to be tested; ρ is the test coefficient; and j is the lag length chosen for ADF such that μ_t is empirical white noise. Here the significance of p is tested against the null that, based on t-statistics on obtained from the OLS estimates of Eq. 3. Thus if the null hypothesis of non-stationary cannot be rejected, the variables are differenced until they become stationary, that is until the existence of a unit root is rejected, before proceeding to test for co-integration.

Test for co integration: The purpose of the co integration test is to determine whether a group of non-stationary series are co integrated or not. It is pointed out that a linear combination of two or more non-stationary series may be stationary. Thus, if such a stationary linear combination exists, the non-stationary time series are said to be co integrated. The stationary linear combination is called the co integrating equation and may be interpreted as a long-run equilibrium relationship among variables.

To test for co integration, we consider the vector error correction model specification in Eq. 1. Information about the number of co integrating relationships among the variables in Z_t is given by the rank of the Π-matrix: if

II is of reduced rank, the model is subject to a unit root; and if $0 < r < n$, where r is the rank of II, II can be decomposed into two (n x r) matrices α and β, such that $II = \beta'Z_t$, where $\beta'Z_t$ is stationary. Here, α is the error correction term and measures the speed of adjustment in ΔZ_t and β contains r distinct co integrating vectors, that is co integrating relationships between non-stationary variables, as earlier stated.

The Johansen method uses the reduced rank regression procedure to estimate α and β and the trace test and maximal-eigen value test statistics were used to test the null hypothesis of at most r co integrating vectors against the alternative that it is greater than r. The interest here is in testing for the presence of a valid co integrating vector which gives a unique long-run equilibrium relationship. Once this is established, the vector error correction model of the form given below can be estimated:

$$\Delta LnA_t = \delta_{10} + \sum_{i=1}^{n} \delta_{11i} \Delta LnA_{t-i} + \sum_{i=1}^{n} \delta_{12i}$$
$$\Delta LnP_{t-i} - \alpha_1 (LnA - LnP)_{t-1} + D01 + U_{1t} \qquad (4)$$

$$\Delta LnP_t = \delta_{20} + \sum_{i=1}^{n} \delta_{21i} \Delta LnA_{t-i} + \sum_{i=1}^{n} \delta_{22i}$$
$$\Delta LnP_{t-i} - \alpha_2 (LnA - LnP)_{t-1} + D01 + U_{2t} \qquad (5)$$

where, all the variables are as earlier defined and Δ is the first difference operator, while δ_{11} and δ_{22} are short-run coefficients and α_1 and α_2 are error correction mechanisms that measure the speed of adjustment from short-run disequilibria to long-run steady-state equilibrium. U_{1t} and U_{2t} are error terms assumed to be distributed as white noise. Real prices were obtained by deflating the nominal prices with the *boro* paddy price (competing crop). All the estimations were performed using the Standard Version of Eviews-6 Econometric Software (Edet *et al.*, 2007).

RESULTS AND DISCUSSION

Table 2 shows the summary results of unit root test of individual series used in the estimations. Calculated ADF statistics for log-level series of Ln At (area under potato) was-0.150434 and LnPt (price of potato) was-2.624128, which were smaller in absolute term than their respective critical value-3.724070. It indicated that they were not stationary (that is contained a unit root), thus the null hypothesis of the presence of a unit root could be rejected, as they are all integrated of order one, that is I (1). Consequently, we applied the ADF test on the log of the differenced series, to make them stationary. The calculated ADF test statistics in this case are higher in

Table 2: Results of Augmented Dickey Fuller (ADF) unit root tests

Variable level	ADF static	Critical value	Variable first difference	ADF static	Critical value
LnA_t	-0.150434	-3.724070	LnA_t	-5.285309	-3.724070
lnP_t	-2.624128	-3.769597	lnP_t	-4.726094	-3.769597

Critical value of ADF tests are based on one-sided p-values. Lag length selection was automatic based on Eviews' schwarz information criteria

absolute terms than the critical values, thus we reject the null hypothesis of the presence of unit root and proceed to test for cointegration. Since the time series are non-stationary, it becomes necessary to test for cointegration. By using the log-level form of the series, we estimate a multivariate cointegration relationship to establish the existence of a long-run equilibrium relationship.

The Johansen's Maximum Likelihood cointegration test relations were estimated with intercept and linear deterministic trend in a Vector Auto Regression (VAR) model of order 3 with a lag length of 3, which was found to be the most parsimonious for the data series. The Johansen cointegration tests are based on the Maximum Eigenvalue of the stochastic matrix as well as the Likelihood ratio test which is in turn based on the Trace of the stochastic matrix. Table 3 shows the summary results of the Johansen's Maximum Likelihood cointegration test. For the null hypothesis of r = 0, the calculated trace statistics was 45.63471 which was larger than its critical value 42.91525 and calculated maximum eigenvalue was 30.95977 which was larger than its critical value 25.82321 at 5% level of significance.

From our results, it is evident that both the trace test and maximum eigenvalue test indicate one cointegrating equation as the null hypothesis of r = 0 is rejected. Thus, we conclude that there is a unique long-run equilibrium relationship between potato supply and real potato price.

The Johansen model is a form of VECM and where only one cointegrating vector exists, its parameters can be interpreted as estimates of the long-run cointegrating relationship between the variables concerned (Hallam and Zanoli, 1993). Our cointegration coefficients normalised on potato supply are presented as long-run estimates in Table 4 in the section that follows.

Table 4 shows the results of the VECM estimates for supply response of potato to changes in real prices. Both the short and long run estimates as well as diagnostics are presented. From the results, it can be observed that the model fits the observed data fairly well and significance of estimated relationships as indicated by the adjusted R^2 (0.759077) and F-statistic (9.270619) of the relevant error correction equation.

Moreover, the signs of the coefficients meet a priori expectations. These together imply that potato supply

Table 3: Results of multivariate cointegration tests

Null hypothesis	Eign values	Trace statistic	Critical value (0.05)	Prob.	Null hypothesis	Max-Eigen statistic	Critical value (0.05)	Prob.
r = 0*	0.724727	45.62471	42.91525	0.0261	r = 0*	30.95977	25.82321	0.0096
r = 1	0.337693	14.66494	25.87211	0.6024	r = 1	9.888614	19.38704	0.6308
r = 2	0.180461	4.776322	12.51798	0.6287	r = 2	4.776322	12.51798	0.6287

Table 4: Long-run and short-run VECM estimates

Regressor	Long-run estimates
LnAt(-1)	1.000000
LnPt(-1)	0.616670 (7.70064)
@Trend(1)	-0.046159 (-11.4964)
Constant	-4.148124

	Short-run estimates	
Error correction	ΔLnAt	ΔLnPt
Coint Eq.1 (ECM(-1))	-1.183760 (-6.81863)	-0.748361(-1.53792)
ΔLnAt(-1)	0.170002 (1.21707)	0.528903 (1.35092)
ΔLnAt(-2)	0.0122138 (0.90269)	0.213844 (0.563861)
ΔLnPt(-1)	0.445002 (4.569871)	-0.333454 (-1.22171)
ΔLnPt(-2)	0.336121 (4.05684)	-0.466339 (-2.00809)
Constant	0.532605 (1.12350)	-0.592849 (-0.44617)
LnAt(1)	-0.144886 (-1.52591)	0.098052 (0.36842)
LnPt(1)	-0.064871 (-0.66255)	-0.304512 (-1.10958)
Dummy(D01)	0.618906 (6.50576)	0.040867 (0.15326)
R^2	0.850857	0.563215
Adj. R^2	0.759077	0.294424
S.E. equation	0.065580	0.183816
F-static	9.270619	2.095363
Log likelihood	34.50890	11.83437
Akike AIC	-2.318991	-0.257670
Schwarz SC	-1.872655	0.188666

response in Bangladesh largely depended on real potato price during the period under study.

Potato is grown commercially and area allocation is influenced by real price changes. In the short-run, the relevant real potato price elasticity is 0.445002 and it is significant at the 1% level while in the long-run, the real potato price elasticity is 0.616670 which is equally significant at the 1% significance level. Clearly, both coefficients are inelastic and suggest that a 100% increases in potato price (relative to boro paddy price) results in an increase by 45% in the following year while the same percentage increase would raise the supply of potato by 62% in the long-run. By using Nerlovian Area (Partial) Adjustment Model, Huq *et al.* (2007) obtained 0.12 as short-run elasticity and 1.88 long-run elasticity with respect to price for the period 1982-83 to 1997-98. Short-run and long-run price elasticities of potato for Bangladesh were observed at 0.0016 and 0.0164 by Sabur for the period 1960-61 to 1981-82 by Sabur (1983), while Rahman (1986) estimated short-run price elasticity for potato at 0.19 for the period 1972-73 to 1981-82. Alam (2001) found short-run price elasticity at 0.06 for the period 1971-95. Previous studies does not consider the unit root problem (i.e., a nonstationarity situation) problem of time series data. If unit root problem exists in the time series data than it resulted spurious result. Present study considered this problem and obtained result is more realistic.

Dummy variable indicate that inclusion of potato in the export trade basket and establishment of export oriented potato flakes industries in the middle of 1990's decade have a highly significant positive effect on potato supply.

By the same token, the coefficient of the dummy variable is highly significant, it indicates a positive relationship with potato supply.

The error correction coefficient (-1.183760), which measures the speed of adjustment towards long-run equilibrium carries the expected negative sign and it is highly significant at the 1% level. The coefficient indicates a feedback of about 118.38% of the previous year's disequilibrium from the long-run elasticity of potato price. This implies that the speed with which potato price adjust from short-run disequilibrium to changes in potato supply in order to attain long-run equilibrium is 118.38% within one year.

CONCLUSIONS

The supply elasticities of potato area in respect to its price are significantly positive for Bangladesh. Therefore, price policies will be effective for obtaining the desired level of output. But the low price elasticity suggests that any form of pricing policy related to potato will be a costly mean of stabilising production.

The estimated functions support the hypothesis that the producer reacts to harvest prices. Therefore, if intervention in the market is to be made as a policy instrument, then it must be implemented during the harvest season for altering price expectations.

Therefore, an institutional arrangement like price commission manned dominantly by the agricultural economists (price specialists) need to be constructed, who will formulate a well designed and effective pricing policy considering the crop sector as a whole, costs and returns of crops, forecasting production changes, determine extent of price support and needed input subsidies etc.

Area changes for potato up to the desired level can be effected for potato by easing out constraint like meeting quality seed requirement, fertilizer, institutional credit, fuel/oil for irrigation, machine tillage etc. for attaining more market responsiveness.

Technological advancement or yield of potato is stagnate for the study period. Technology for increasing yield needs to be developed which can be possible by

increasing budgetary allocation for varietals improvement and production management research and increasing efficiency and accountability thereon.

Emphases should also to be given to increase potato export and establishing export oriented potato processing industries.

Farmers also face many difficulties and different types of malpractice for potato marketing. These are unavailability of cold storage space (this situation arises sometimes due to fictitious bookings and holding space for thousands of bags for businessmen who are regular customers), cold storage owner charge more for storing smaller quantity of potato, compensation is rarely given for damaged or rotten potatoes which happen while it is in cold storage, low price during harvesting period, producers' share to consumer price is low, high marketing cost, seasonal variation in prices, powerful middlemen manipulate and control the price, lack of adequate market infrastructure like road communication and transport media, lake of modern price information system etc.

Future research needed on how to improve marketing efficiency through improving marketing activities, export potentiality, supply chain and value chain analysis and demand-supply estimation within a simultaneous equation model.

REFERENCES

Afsar, A.K.M.N., 1997. Food security in Bangladesh. Agric. Market., 40: 5-20.

Alam, S., 2001. A study on farm mechanisation and labour demand in crop production activities in Bangladesh. Draft Report. Bangladesh Agricultural Research Council (BARC) and Bureau of Socio-Economic Research and Training (BSERT), Bangladesh Agricultural University, Mymensingh.

Banerjee, A., J.J. Dolado and R. Mestre, 1998. Error correction mechanism tests for co integration in a single-equation framework. J. Time Ser. Anal., 19: 267-285.

BBS, 1987. Yearbook of Agricultural Statistics of Bangladesh, 1985-86. Statistics Division, Ministry of Planning, Government of the People's Republic of Bangladesh.

BBS, 1993. Yearbook of Agricultural Statistics of Bangladesh, 1992. Statistics Division, Ministry of Planning, Government of the People's Republic of Bangladesh.

BBS, 1995. Yearbook of Agricultural Statistics of Bangladesh, 1995. Statistics Division, Ministry of Planning, Government of the People's Republic of Bangladesh.

BBS, 1998. Yearbook of Agricultural Statistics of Bangladesh, 1997. Statistics Division, Ministry of Planning, Government of the People's Republic of Bangladesh.

BBS, 2008. Yearbook of Agricultural Statistics of Bangladesh, 2007. Statistics Division, Ministry of Planning, Government of the People's Republic of Bangladesh.

Brescia, V. and D. Lema, 2007. Supply Elasticities for Selected Commodities in Mercosur and Bolivia. EC Project EUMercoPol (2005-08), Instituto de Economía y Sociología, INTA (Argentina).

Chang, H.S. and G. Griffith, 1998. Examining long-run relationships between Australian beef prices. Aust. J. Agric. Resour. Econ., 42: 369-387.

Edet, E.O., H.M. Ndifon and N.M. Nkang, 2007. Maize supply response to changes in real prices in Nigeria: A vector error correction approach. Agric. J., 2: 419-425.

Elbeydi, K.R., A.A. Aljdi and A.A. Yousef, 2007. Measuring the supply response function of barley in Libya. Afr. Crop Sci. Confer. Proc., 8: 1277-1280.

Griliches, Z., 1959. The demand for inputs in agriculture and derived supply elasticity. J. Farm Econ., 40: 309-322.

Hallam, D. and R. Zanoli, 1993. Error correction models and agricultural supply response. Eur. Rev. Agric. Econ., 20: 151-166.

Huq, A.S.M.A., S. Alam and S. Akhter, 2007. Supply response of potato in Bangladesh. Bangladesh J. Agric., 32: 71-80.

Islam, M.T., 1987. An economic study of potato preservation in cold storage in some selected areas of Bangladesh. Master's Thesis, Department of Co-operation and Marketing, Bangladesh Agricultural University.

Johansen, S. and K. Juselius, 1990. Maximum likelihood estimation and inference on cointegration-with applications to the demand for money. Oxford Bull. Econ. Stat., 52: 169-210.

Johansen, S., 1991. Estmation and hypothesis testing of cointegration vectors in Gaussian Vector autoregressive models. Econometrica, 59: 1551-1580.

Johnston, J. and J. DiNardo, 1997. Econometric Methods. 4th Edn., McGraw Hill, New York.

McKay, A., O. Morrisey and C. Vaillant, 1999. Aggregate supply response in Tanzanian agriculture. J. Int. Trade Econ. Dev., 8: 107-123.

Mohammad, S., M.S. Javed, B. Ahmad and K. Mushtaq, 2007. Price and non-price factors affecting acreage response of wheat in different agro-ecological zones in Punjab: A co-integration analysis. Pak. J. Agric. Sci., 44: 370-377.

Muchapondwa, E., 2008. Estimation of the aggregate agricultural supply response in Zimbabwe: The ARDL approach to cointegration. Working Paper Number 90, School of Economics, University of Cape Town.

Narayan, P.K., 2005. The saving and investment nexus for China: Evidence from cointegration tests. Applied Econ., 37: 1979-1990.

Nerlove, M., 1958. The Dynamics of Supply: Estimation of Farmers' Response to Price. 1st Edn., Johns Hopkins University Press, Balti-More,.

Nerlove, M. and K.L. Bachman, 1960. The analysis of changes in agricultural supply: Problems and approaches. J. Farm Econ., 3: 531-554.

Nerlove, M., 1979. The dynamics of supply: Retrospect and prospect. Am. J. Agric. Econ., 61: 874-888.

Nickel, S., 1995. Error correction, partial adjustment and all that: An expository note. Oxford Bull. Econ. Stat., 47: 119-129.

Ocran, M.K. and N. Biekpe, 2008. Agricultural commodity supply response in Ghana. J. Econ. Stud., 35: 224-235.

Pesaran, H.M., Y. Shin and R.J. Smith, 2001. Bounds testing approaches to the analysis of long-run relationship. J. Applied Econ., 16: 289-326.

Rahman, S.H., 1986. Supply response in Bangladesh agriculture. Bangladesh Development Studies.

Sabur, S.A., 1983. Demand, supply and price structure of potato in Bangladesh. Ph.D. Thesis, College of Agriculture, Haryana Agricultural University, Hisar.

Thiele, R., 2000. Estimating aggregate agriculture supply response: A survey of techniques and results for developing countries. Keil Working Paper No. 1016, Keil Institute of World Economics, Germany.

Thiele, R., 2003. Price incentives, non-price factors and agricultural Production in Sub-Saharan Africa: A cointegration analysis. Proceedings of the 25th International Conference of Agricultural Economists (IAAE), Aug. 16-22. Durban, South Africa.