Scientific Research and Essays Vol. 7(38), pp. 3262-3268, 27 September, 2012
Available online at http://www.academicjournals.org/SRE
DOI: 10.5897/SRE10.487
ISSN 1992-2248 ©2012 Academic Journals

Full Length Research Paper

Supply response of mustard in Bangladesh: A cointegration analysis

A. S. M. Anwarul Huq*, Fatimah Mohamed Arshad and Md. Ferdous Alam

Institute of Agricultural and Food Policy Studies, Universiti Putra Malaysia, Putra Infoport, Jalan Kajang-Puchong, 43400 UPM Serdang, Selangor, Malaysia.

Accepted 3 September, 2012

An attempt has been made in this study to examine the supply response of mustard through cointegration and vector error correction approach. Augmented Dickey-Fuller (ADF) test indicates that all the variables considered have a unit root problem at level form and is stationary at differenced form for which all the data series are I(1). The trace statistic and maximum eign value tests confirm that there is at least one cointegrating vector. The short-run elasticity with respect to real mustard price is 0.1543 while in the long-run, the real mustard price elasticity is 0.5242. In the short-run impact of price fluctuation is very little or minimum. The mustard area is inelastic with respect to own price. Low short-run and long-run elasticities of supply indicate that mustard growers do not make considerable area adjustments in response to expected prices. Weather variable emerges as one of the important factors in determining the mustard area in the short-run. Due to low price elasticity, price policies will not be much effective in obtaining the desired level of mustard output.

Key words: Supply elasticity, mustard, vector error correction.

INTRODUCTION

Mustard is cultivated for oilseed production and almost entirely confined to the temperate and warm temperate zones of Asia and Europe. It grows widely in China, India, Bangladesh, Pakistan, Canada, Sweden and Poland. It is also grown in some other countries of Asia, Europe and Africa on small scale.

Rapeseed and mustard (*Brassica* spp.) are important edible oil crops of Bangladesh. For rapeseed and mustard, the commonly used term is ‘mustard’. In Bangladesh, mustard is called "*Sharisha*". Although it has a much less important position than many other oilseeds in the world, it is the important source of edible oil in Bangladesh and meets about one-third of the total requirements of edible oil in Bangladesh. Mustard seeds contain 40 to 45% oil and 20 to 25% protein. Using local “G*hani”* (traditional mustard oil extraction method) 33% oil may be extracted on an average. Oil cake, the by-product of mustard, is a nutritious food item for cattle and fish. It is a good organic fertilizer too. Efforts are being made by the government towards boosting the mustard production to meet the increasing demand for the fast growing population.

The shortage of edible oil has been prevailing in Bangladesh for a long time. The country is deficit in edible oil production by about 70%. Though oil production has been increasing gradually yet it cannot keep pace with population growth. It tops the list in respect of area and production among all the oil crops grown in the country. It may be mentioned here that only 4.2% of the total cultivated area is devoted to the production of oil crops which contributes around 1.6% of the total agricultural product. The area under oilseed crops was 385.2 thousand hectares in 1984 to 1985 and is reduced subsequently to 216.8 thousand hectares in 2005 to 2006. Annual production of different oilseeds was 285 thousand tons in 1984 to 1985 and 183.5 thousand tons in 2005 to 2006 (BBS, 2008). Its per hectare yield is only about 800 kg. Although, mustard is the principal oilseed crop in Bangladesh, its cultivation is much neglected. Total production and per hectare seed yield of mustard may be increased by applying improved production

*Corresponding author. E-mail: anwarul.huq09@gmail.com. Tel: +88-02-9126662, +88-01715226468.

technology. Farmers have been giving much emphasis to cultivate more and more of cereals like rice. As a result the area under oilseeds declined substantially. The static or declining trend in area and production of oilseeds in recent years has become a serious concern to the planners and policy makers in the country. Bangladesh agriculture has attained its extensive margin of cultivation of land and there is practically no additional land to be brought under new cultivation (Alam, 1991). To attain self-sufficiency for food supply in Bangladesh, priority has shifted to diversification of crop production from the mono crop approach.

Mustard is one of the most important oilseed crops for Bangladesh. Farmers cultivate it with their innovative ideas on variety, fertilizer dose and agronomic practices. Mustard plays a vital role in the domestic supply of edible oil in Bangladesh. With the increase of population pressure, the demand for edible oil is increasing day by day. The growth in mustard output has lagged far behind the growth in demand which is forcing the government to resort to large-scale import of edible oils to bridge the gap. In recent years this problem is becoming more acute because with increased irrigation facilities, the farmers are more interested to grow high value crops rather than producing minor crops. Considering the sizeable drain of foreign exchange due to edible oil imports to meet domestic requirements, the efforts towards achieving self-sufficiency in mustard oil seed production is very much essential.

In designing appropriate policies for maintaining a stable supply of commodity over time, estimates of demand and supply of agricultural commodities are very essential. Accurate knowledge of supply is essential not only for formulating suitable sets of policies but also for better guidance and decision making to individual farmers. Supply responses estimation will help farmers adjust their production to maximize their profit with projected prices. But investigation on farmers’ response to various price and non-price factors for area allocation of mustard is very scanty.

Previous supply response studies in Bangladesh such as Matin and Alam (2004) for wheat, Sabur (1984) for potato, Rahman (1986) for crops, Alam (1991) for major crops, Yunus (1993) for crops, Jabber et al. (1997) for rice, used classical regression analysis mainly Nerlove’s (1958) restrictive adaptive expectations/partial adjustment model(s). These studies used time series data ignoring unit root problem of time series data and poses the danger of spurious regression (Granger and Newbold, 1974; Nelson and Plosser, 1982; Townsend, 1997). The Nerlovian Partial Adjustment models do not give an adequate distinction between short and long-run elasticities (McKay et al., 1999; Townsend, 1997). The dynamics of supply can be better described by Error-Correction Models (ECM) than Partial Adjustment Models (McKay et al., 1999; Hallam and Zanoli, 1993). In recent years, cointegration, error correction model and vector error correction approach has been widely used by different economists for supply response estimation (Mohammad et al., 2007; Nkang et al., 2007; Engler and Nahuelhual, 2006; Vickner and Davis, 2000; Thompon et al., 2002; Sephton, 2003; Brescia and Lema, 2007; Elbeydi et al., 2007; Thiele, 2003).

Since supply response study of mustard is very scanty, it is very timely to have a study on this. The study is expected to provide more rational elasticity figures for use by the decision makers. It is with this backdrop, the present study has been conducted to examine the supply response of mustard using cointegration and vector error correction approach, an approach more suitable for time-series modeling.

MATERIALS AND METHODS

Data source

Time series data were collected from different statistical yearbooks of Bangladesh Bureau of Statistics (BBS), Ministry of Planning, and Government of the People's Republic of Bangladesh. Data for the period (1972 to 1973) to (2005 to 2006) were used in present study, after the independence of the country (taken from BBS, 1982, 1998, 2004, 2005 and 2008). The database consists of area, production and price of mustard seed, wheat, *Boro* paddy, pulse and potato.

The variables chosen are: mustard area (MA), deflated mustard price (MP), deflated potato price taken as competitive crop (PP) and proxy variable for weather (WE). All the variables were taken in natural logarithm except the proxy variable for weather (WE). The impact of weather on mustard yield variability is measured with a Stalling index (Stalling, 1960). Yield is regressed on time to obtain expected yield. The actual to the predicted yield ratio is defined as the weather variable. The weather effects such as rainfall, temperature etc. may be captured by this index in supply response model. Data on infrastructural developments, expenditure on agricultural research and extension, applications of modern techniques like fertilizers and improved varieties etc, are not easily available and therefore, could not be considered. To capture their effects collectively, time-trend dummy variable was incorporated.

Nominal harvest price was deflated with the Laspeyres price index (using base year weights). The Laspeyres price index was constructed for *Boro* paddy, chick pea, mung bean, lentil, potato and mustard harvest price as they are competing crops of mustard and all are grown in *Rabi* season. The Laspeyres price index can be written in terms of a mathematical formula as follows (Koop, 2009):

$$LPI_t = \frac{\sum_{i=1}^{n} P_{it} Q_{i,base\ year}}{\sum_{i=1}^{n} P_{i,base\ year} Q_{i,baseyear}} \times 100$$

Farmers have greater control over the area than on production or output, therefore planted area is taken instead of output in the present study. Most of the farmers in Bangladesh dispose off their products just after the harvest and farmers make planting decisions based on their expectation of prices to be received after harvesting, that is why the harvest price is considered important in the present analysis.

Analytical framework

In applied econometric work, standard classical methods of estimation are based on the assumption that the means and variances of the variables are well-defined constants and independent of time. Non-stationary or unit root variables are those variables means and variances of which change over time. Using classical estimation methods, such as the ordinary least squares (OLS), to estimate relationships with unit root variables gives misleading inferences. This is known as the spurious regression problem. Cointegration is the appropriate technique to estimate the equilibrium or long-run parameters in a relationship with unit root variables. Generally, four major steps are applied in unit root and cointegration techniques. Firstly, unit root test are applied to determine whether the variables in the model are stationary or non-stationary. Secondly, cointegrating regressions are estimated for the long-run or equilibrium relationships. Thirdly, the short-run or the dynamic disequilibrium relationships are estimated. Lastly, the robustness of the estimated dynamic disequilibrium relationships is determined by subjecting them to the standard diagnostic tests (Rao, 2007).

Although there is a similarity between the tests for cointegration and unit roots, these tests are not identical. Tests for unit roots are performed on univariate time-series. In contrast, cointegration deals with the relationship among a group of variables, where (unconditionally) each has a unit root. In the applied econometric works some widely used unit root tests are the Augmented Dickey-Fuller test (ADF). These tests can be implemented with many standard software packages like Eviews, RATS, SHAZAM, CATS, Microfit (version 4.1) etc. Eviews (version 6) has been used to estimate the models in this study.

Testing for unit roots

In order to avoid the problem of spurious regression for time series, it is required to conduct a test for the presence of unit roots. There are several ways of testing for the presence of unit root like Dickey-Fuller (DF) approach, Augmented Dickey-Fuller (ADF) approach, CRDW-test, Phillips-Perron-type test etc. Augmented Dickey-Fuller (ADF) test is most widely used for unit root test. In the present study, the use of ADF test has been made.

The simplest form of the DF test amounts to estimating:

$$y_t = \rho_\alpha y_{t-1} + u_t$$

or

$$(1-L)y_t = \Delta y_t = (\rho_\alpha - 1)y_{t-1} + u_t \quad \text{where} \quad u_t \sim IID(0,\sigma^2) \qquad (1)$$

Either variant of the test is applicable, with the null hypothesis being $H_0{:}\rho_\alpha = 1$ against the alternative $H_1{:}\rho_\alpha < 1$.

Testing for a unit root using (1) involves making the prior assumption that the underlying d.g.p. (data generating process) for y_t is a simple first-order autoregressive process with a zero mean and no trend component (that is no deterministic variables). Using regression equation (1) is only valid when the overall mean of the series is zero. When the underlying d.g.p. is given by (1), it is not known whether y_0 in the d.g.p. equals zero, then it is better to allow a constant μ_b to enter the regression model when testing for a unit root:

$$\Delta y_t = \mu_b + (\rho_b - 1)y_{t-1} + u_t \text{ where } u_t \sim IID(0,\sigma^2) \qquad (2)$$

However, (2) cannot validly be used to test for a unit root when the underlying d.g.p. is also given by (2). In this instance, if the null hypothesis is true $\rho_b = 1$, and y_t will follow a stochastic trend, that is, it will drift upwards or downwards depending on the sign of μ_b. Under the alternative hypothesis that $\rho_b < 1$, then y_t is stationary around a constant mean of $\mu_b/(1 - \rho_b)$, but it has no trend. It is necessary to have as many deterministic repressors as there are deterministic components in the d.g.p., and have to allow a time trend *t* to enter the regression model used to test for a unit root:

$$\Delta y_t = \mu_c + \gamma_c t + (\rho_c - 1)y_{t-1} + u_t \text{ where } u_t \sim IID(0,\sigma^2) \qquad (3)$$

The t-tests of the null hypothesis of a unit root must use critical values from the DF distribution and not the standard t-distribution. Similarly, F-tests of joint hypotheses concerning the unit root and the significance of constant or trend terms must also use the critical values of the appropriate DF distribution. It is necessary to ensure that the regression model used for testing has more deterministic components than the hypothesized data generating process (d.g.p.), otherwise the test will not nest the null and alternative hypotheses. In general, since the underlying d.g.p. is unknown, this suggests using (3) for testing the unit hypothesis. However, having unnecessary nuisance parameters (constant and trend terms) will lower the power of the test against alternatives.

If a simple AR(1) DF model is used when in fact y_t follows an AR(p) process, then the error term will be autocorrelated to compensate for the misspecification of the dynamic structure of y_t. Autocorrelated errors will invalidate the use of the DF distributions, which are based on the assumption that u_t is 'white-noise'. Thus, assuming that y_t follows a p^{th} order autoregressive process:

$$y_t = \psi_1 y_{t-1} + \psi_2 y_{t-2} + ... + \psi_p y_{t-p} + u_t$$

or

$$\Delta y_t = \psi^* y_{t-1} + \psi_1^* \Delta y_{t-1} + \psi_2^* \Delta y_{t-2} + ... + \psi_{p-1}^* \Delta y_{t-p+1} + u_t$$
$$u_t \sim IID(0,\sigma^2) \qquad (4)$$

Where $\psi^* = (\psi_1 + \psi_2 + \ldots\ldots + \psi_p) - 1$. If $\psi^* = 0$, against the alternative $\psi^* < 0$, then y_t contains a unit root. To test the null hypothesis, we calculated the DF t-statistic ($\hat{\Psi}^* / se(\hat{\Psi}^*)$), which can be compared against the critical values (for τ) (Harris, 1995).

The Johansen cointegration approach / vector error correction model (VEC)

In previous literature it was found that VEC model is appropriate for non-stationary time series with a common long-term trend. Although the variables may exhibit a dynamic of their own in the short-run, they tend to move together in the long-run. VEC models have been applied in numerous studies and it is relevant for supply response studies (Nkang et al., 2007; Olubode-Awosola et al., 2006; Engler and Nahuelhual, 2006; Vickner and Davis, 2000; Thompon et al., 2002; Sephton, 2003).

After establishing the order of integration of time series data, to use cointegration, we applied Johansen's approach (1988) which provides likelihood ratio tests for the presence of number of cointegrating vectors among the series and produces long-run elasticities. It is hypothesized that mustard area and real mustard price are jointly determined (that is endogenous to the system) while the other variables (as expected) is exogenous to the system.

The Johansen maximum likelihood approach for multivariate cointegration is based on the following VAR model:

$$z_t = A_1 z_{t-1} + \ldots\ldots\ldots\ldots + A_k z_{t-k} + u_t \text{ where } u_t \sim IN(0, \Sigma) \qquad (5)$$

where z_t = (nx1) vector of I(1) variable (containing both endogenous and exogenous variables), A_i is an (nxn) matrices of parameters,

Table 1. Results of augmented Dickey fuller (ADF) unit root tests.

Variable level	ADF statistic	Critical value	Variable first difference	ADF statistic	Critical value
LnMA	0.0875	-1.9513	MA	-4.9334	-1.9517
LnMP	-0.6928	-1.9521	MP	-6.7910	-1.9521
LnPP	-0.3094	-1.9521	PP	-7.5409	-1.9521
WE	-0.5342	-1.9513	WE	-4.7905	-1.9517

Critical value of ADF tests are based on Mac Kinnon (1996) one-sided p-values at 5% level. Lag length selection was automatic based on Eviews' Schwarz information criteria.

and u_t is an (n ×1) vector of white noise errors. Equation 5 can be estimated by OLS because each variable in z_t regressed on the lagged values of its own and other variables in the model.

As z_t is assumed to be non-stationary, therefore, to estimate the hypotheses of integration and cointegration in equation (5) we reformulated it into first-difference or vector error correction (VECM) form.

$$\Delta z_t = \Gamma_1 \Delta z_{t-1} + \Gamma_2 \Delta z_{t-2} + ... + \Gamma_{k-1} \Delta z_{t-k+1} + \pi z_{t-k} + u_t \quad (6)$$

where $\Gamma_i = -(I - A_1 - ..... - A_i)$, (i = 1, …, k-1), and $\pi = -(I - A_1 - ..... - A_k)$. This specification provides information regarding short and long-run adjustments to changes in z_t through the estimates of $\hat{\Gamma}$ and $\hat{\Pi}$ respectively. The term πz_{t-k} gives information about the long-run equilibrium relationship between the variables in z_t. The information about the number of cointegrating relationship between the variables in z_t is given by the rank of the matrix π. If the rank of π matrix r is 0< r <.n, there are r linear combination of variables in z_t that are stationary. Here the π matrix can be decomposed into two matrices α and β such that π = α β, where α is error correction term, which measures the speed of adjustment in Δz_t , while β contains r distinct cointegrating vectors, showing cointegrating relationship between the non-stationary variables. A large value of α means that the system will respond to a deviation from long-run equilibrium very quickly (that is, with a rapid adjustment) and *vice versa.*

The purpose of the cointegration test is to determine whether a group of non-stationary series is cointegrated or not. 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 cointegrated. The stationary linear combination is called the cointegrating equation and may be interpreted as a long run equilibrium relationship among variables. The cointegration test carried out using the Johansen's Maximum-Likelihood procedure provides more robust results when there are more than two variables in the model. The Johansen cointegration analysis is performed on the unrestricted VAR using a maximum likelihood estimator. The objective is to estimate the long run matrix Γ, and subsequently determine its rank (the rank also indicates the number of cointegrating vectors in the VAR). The Johansen method provides two likelihood ratio tests, namely the Trace and the Maximum Eigenvalue statistic tests, which are used to determine the number of co-integrating equations given by the co-integration rank r. A co-integration equation is the long-run equation of co-integrated series. The Trace statistic tests the null hypothesis of *r* co-integrating relations against the alternative of *k* co-integrating relations, where k is the number of endogenous variables for $r = 0, 1,..., k - 1$. The maximum eigenvalue statistic tests the null hypothesis of *r* co-integrating vectors against the alternative of $r + 1$ co-integrating vectors.

When the co-integration rank r is equal to 1, the Johansen single equation dynamic modeling and the Engle-Granger approaches are both valid. When r equals 1, the normalization restriction for the parameters produces a unique estimate of what the economic theory suggests. However, when there is more than one co-integration equation the Johansen approach to co-integration analysis is preferred to the Engle-Granger approach (Kremers et al., 1992).

Given the above vector error correction model in Equation 1, the long-run co integrating equation for mustard can be written as:

$$LnMA_t = \phi_0 + \phi_1 LnMP_t + e_t \quad (7)$$

where: MA_t is mustard area; MP_t is deflated mustard price; 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 (Mohammad et al., 2007; Nkang et al., 2007; Olubode-Awosola et al., 2006; Harris, 1995).

RESULTS

Tests for order of integration

The results of ADF for unit root tests are presented in Table 1. Tests are applied to all the series for both 'levels' and the 'first differences'. The null hypothesis is accepted in all cases at levels at 5% level of significance. ADF statistics for log-level series of MA (area under mustard) was 0.087493, MP (price of mustard) was -0.692787, PP (price of potato) was -0.309398 and WE (weather) was -0.534248, which were smaller in absolute term than their respective critical value. It indicated that they were not stationary and contained a unit root. Consequently we applied the ADF test on first differences of all the series. At first difference, the ADF test statistics were larger than the MacKinnon critical values of all the series at 1% levels of significance, thus we reject the null hypothesis of the presence of unit root.

Testing for cointegration

The Johansen cointegration tests are based on the

Table 2. Results of multivariate cointegration tests.

Null hypothesis	Eigen values	Trace statistic	Critical value (0.05)	Prob.	Null hypothesis	Max-eigen statistic	Critical value (0.05)	Prob.
r = 0*	0.5683	49.7866	40.1749	0.0041	r = 0*	26.8819	24.1592	0.0209
r = 1	0.3814	22.9048	24.2760	0.0737	r = 1	15.3676	17.7973	0.1118
r = 2	0.2098	7.53723	12.3210	0.2748	r = 2	7.5356	11.2248	0.2064
r = 3	0.0001	0.00166	4.1299	0.9742	r = 3	0.0017	4.1299	0.9742

*Denotes rejection of the hypothesis at the 0.05 level.

Table 3. Long-run and short-run VECM estimates.

Regressor	Long-run estimates	
LnMA (-1)	1.0000	
LnMP (-1)	0.5242 (2.1723)	
Constant	-6.6547	
	Short-run estimates	
Error correction	**ΔLnMA**	**ΔLnMP**
Coint. Equation1 (ECM (-1))	-0.5387 (-8.8778)	-0.2409 (-1.6243)
ΔLnMA (-1)	-0.3251 (-3.1985)	-0.1004 (-0.4042)
ΔLnMA (-2)	-0.1862 (-2.0667)	0.2311 (1.0493)
ΔLnMP (-1)	0.1543 (1.9476)	-0.3059 (-1.5795)
ΔLnMP (-2)	0.0359 (0.4080)	-0.3168 (-1.4722)
Constant	-0.7679 (-9.2725)	-0.3993 (-1.9726)
LnPP	0.0694 (1.2596)	0.2139 (1.5885)
WE	0.7252 (9.8718)	0.2450 (1.3647)
R-squared	0.8632	0.4257
Adj. R-squared	0.8216	0.2509
S.E. equation	0.0573	0.1400
F-static	20.7372	2.4357
Log likelihood	49.2984	21.5930
Akike AIC	-2.6644	-0.8770
Schwarz SC	-2.2944	-0.5069

Figures in parentheses are absolute value of t statistics.

maximum eigen value of the stochastic matrix as well as the likelihood ratio test which is in turn based on the Trace of the stochastic matrix. Results are reported in Table 2. The trace statistic and maximum eign value test statistics shows that only the null hypothesis of at most one co-integration equation cannot be rejected at 5% significance level with the assumption of quadratic deterministic trend in the series. For the null hypothesis, r = 0, the calculated trace statistics was 49.7866 which was larger than its critical value 40.17493 and calculated maximum eigenvalue was 26.88186 which was larger than its critical value 24.15921 at 5% level of significance.

Estimation of vector error correction model

After the long-run relations between area and the variables predicting it are confirmed, a VECM is developed. The results of the VECM estimates for supply response of mustard to changes in real prices of both the short-run and long-run relationships are presented in Table 3. According to Hallam and Zanoli (1993), a high R^2 in the long-run regression equation is necessary to minimize the effect of small sample bias on the parameter estimates of the cointegrating regression, which may otherwise be carried over to the estimates of the error correction model. A glance at the table indicates that all the estimated coefficients have the expected signs. The magnitude of the coefficient of determination, (R^2) is supported by highly significant values of F-statistics, which are significant at 1% level of significance. Based on the value of adjusted R^2, the explanatory variables explained almost 82% of the variation in the dependent variable. Moreover, the signs of the coefficients meet *a priori* expectations.

Results indicate that mustard price coefficient is positive and significant at 10% level of significance in the short-run and 1% level of significance in the log-run, but the coefficient is very small. The short-run elasticity with respect to real mustard price is 0.154293 while in the long-run, the real mustard price elasticity is 0.524164 and both are significant.

Weather variable emerges as one of the important factors in determining the mustard area in the short-run. It is found to be positive and highly significant in case of mustard supply in the country. The coefficient of potato price (competing crop) is positive, which is not expected, but it is insignificant.

The error correction coefficient (-0.815542), 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 that about 82% of deviation from long-run equilibrium is corrected for in any one year.

DISCUSSION

There is strong evidence in the result that unit root non-stationary characterizes the time series data of the variables. The results indicate that all the variables considered in the analysis have a unit root problem at level form and stationary at differenced form. Thus all the data series are I(1). Since all series are integrated of the same order, the series requires a test for the existence of one or more long-run relationships among them that is cointegration. Both the tests (trace statistic and maximum eign value test statistics) confirm that there are at least one cointegrating vectors. Cointegration estimates the long-run relationships among the variables and the error correction models outline the short-run dynamics of the determinants of the long-run variables. The error correction coefficient implies that the speed with which mustard price adjusts from short-run disequilibrium to changes in mustard supply in order to attain long-run equilibrium is 82% within one year. This further confirms once again, the existence of the cointegration relationship in the models.

Results indicate that mustard supply response in Bangladesh largely depends on real mustard price during the period under study. But very small coefficient of real mustard price implies that price does not shift supply appreciably. An increase in mustard price positively affects the mustard area, but it would be very little especially in the short-run. Both the coefficients are inelastic and suggest that a 100% increases in real mustard price results in an increase of only 15% in the following year while the same percentage increase would raise the supply of mustard by 52% in the long-run. In the short-run price fluctuation impact is very little/minimum. The mustard area is inelastic with respect to own price. Low short and long-run elasticities of supply indicate that mustard growers do not make considerable area adjustments in response to expected prices. The positive sign of weather variable indicates that favourable weather condition increase mustard output largely. The insignificant coefficient of potato price (competing crop) means that mustard is not responsive to the price of a competing crop like potato.

By using Nerlovian "Area (Partial) Adjustment Model", Rahman (1986) obtained 0.72 as supply elasticity with respect to price. The relative price elasticities obtained in the present study were lower than previous study. Previous study did not consider the unit root problem (that is, a non-stationary situation) of time series data. If unit root problem exists in the time series data then it results spurious result. Present study has correctly considered this problem and obtained more realistic results.

Conclusion and policy implications

Present paper estimates the long-run relationship between mustard area, price incentives and non-price factors in Bangladesh by Using Johansen's Cointegration approach. Generally, the results conform to *a priori* expectations. Results indicate that farmers' response to producer prices is statistically significant and positive. From the analysis, two basic results emerge. First, the estimated supply elasticities came out to be less than one and appeared not to be high enough to imply that further agricultural reforms are required. Second, weather appeared to be an important non-price variables explaining mustard production, which indicates that good weather conditions positively influence the crop production in Bangladesh.

Supply elasticity would not act as an incentive for mustard growers and still we do not find desired growth in mustard area. Since price elasticity of mustard area is low but significant, price policies will not be effective much in obtaining the desired level of output. Such evidence has been used to argue that farmers are not responsive much to mustard. Government should focus on the policies that ensure the profitable price to the producers in the long-run and emphasis need to be given to technological development. Special emphasis needed for short duration high yielding variety development, which can be fit in the cropping pattern before *Boro* rice cultivation. In Bangladesh, still now farmers cultivate Tori-7 variety of mustard, whose yield level is low. Strong coordination among extension worker, input supply agencies and research is needed to increase overall production of mustard. Quality mustard seed for short duration variety have to be made easily available in the market in the extensive mustard growing area and side by side extension work for mustard production should be strengthened. Complementary interventions, access to input, availability of short duration high yielding variety seed in the local market, improved production technology improved infrastructure, marketing etc, can be expected to make producers more responsive to grow mustard. This latter point is especially important for the expansion of total agricultural output.

REFERENCES

Alam S (1991). The effects of price and non-prices factors on the production of major crops in Bangladesh. Unpublished PhD. Thesis, Department of Agricultural Economics and Food Marketing, University of New Castle Upon Tyne.

BBS (1982). Yearbook of Agricultural Statistics of Bangladesh. Dhaka. Ministry of Planning. Government of the People's Republic of Bangladesh.

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

BBS (2004). Yearbook of Agricultural Statistics of Bangladesh, 2001. Dhaka. Ministry of Planning. Government of the People's Republic of Bangladesh.

BBS (2005). Yearbook of Agricultural Statistics of Bangladesh, 2004. Dhaka. Ministry of Planning. Government of the People's Republic of Bangladesh.

BBS (2008). Yearbook of Agricultural Statistics of Bangladesh, 2006. Dhaka. Ministry of Planning. Government of the People's Republic of Bangladesh.

Brescia V, Lema D (2007). Supply elasticities for selected commodities - in Mercosur and Bolivia. First draft: January 2007, EC Project EUMercoPol (2005-2008), Instituto de Economía y Sociología, INTA (Argentina). Available at: www.inta.gov.ar/ies/docs/otrosdoc/MERCOSUR-Supply_Elasticities.pdf.

Elbeydi KR, Aljdi AA, Yousef AA (2007). Measuring the supply response function of barley in Libya. African Crop Science Society, African Crop Science Conference Proceedings. Printed in El-Minia, Egypt, 8:1277-1280.

Engler A, Nahuelhual L (2006). Response of the Chilean wheat price to changes in international markets: A cointegration analysis. Cien. Inv. Agric. 33(3):211-218.

Granger CWJ, Newbold P (1974). Spurious regressions in econometrics. J. Econom. 2:111-120.

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

Harris RID (1995). Using cointegration analysis in econometric modeling. Prentice Hall/Harvester Wheatsheaf, London.

Jabber MA, Alam MS, Islam MS (1997). Rice, risk and rationality: explorations in supply response in Bangladesh. Bangladesh J. Agric. Econs. 20(1):1-13.

Kremers J, Ericsson N, Dolado J (1992). The power of co-integration tests. Oxf. Bull. Econ. Stat. 54(3):325-348.

Koop G (2009). Analysis of economic data, Third Edition. Wiley, A John Wiley & Sons, Ltd, Publication. pp. 24-26.

Matin MA, Alam S (2004). Demand, supply estimation and projection of wheat situation in Bangladesh. Bangladesh J. Agric. Econ. 27(2):25-44.

McKay A, Morrisey O, Vaillant C (1999). Aggregate supply response in Tanzanian agriculture. J. Inter. Trade Econ. Develop. 8(1):107-123.

Mohammad S, Javed MS, Ahmad B, Mushtaq K (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(2):370-377.

Nerlove M (1958). The dynamics of supply*:* Estimation of farmers*"* response to price*.* Baltimore*:* Johns Hopkins University Press. ix:267.

Nelson C, Plosser C (1982). Trends and random walks in macroeconomic time series: some evidence and implications. J. Monetary Econ. 10:139-163.

Nkang NM, Ndifon HM, Edet EO (2007). Maize supply response to changes in real prices in Nigeria: A vector error correction approach. Agric. J. 2(3):419-425.

Olubode-Awosola OO, Oyewumi OA, Jooste A (2006). Vector error correction modeling of Nigerian agricultural supply response. Agrekon. 45(4):421-436.

Rahman SH (1986). Supply response in Bangladesh Agriculture. Bangladesh Dev. Stud. 14:57-100.

Rao BB (2007). Cointegration for the applied economist. Second Edition, Palgrave Macmillan, New York, USA. 1:3-11.

Sabur SA (1984). Acreage response for potato in Bangladesh. Bangladesh J. Agric. Econ. 7(2):57-62.

Sephton PS (2003). Spatial market arbitrage and threshold cointegration. Am. J. Agric. Econ. 85(4):1041-1046.

Stalling JL (1960). Weather indexes. J. Farm Econ. 42:180-186.

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) 16-22 August 2003. Durban, South Africa.

Thompon S, Sul D, Bohl M (2002). Spatial market efficiency and policy regime change: seemingly unrelated error correction estimation. Am. J. Agric. Econ. 84(4):1042-1053.

Townsend R (1997). Policy distortions and agricultural performance in the South African economy. Development Bank of Southern Africa, Dev. Inf. Bus. Unit. Discuss. Paper p. 138.

Vickner S, Davies S (2000). Estimating strategic price response in a product-differentiated oligopoly: the case of a domestic canned fruit industry. Agribusiness 16(2):125-140.

Yunus M (1993). Farmer’s response to price in Bangladesh. The Bangladesh Dev. Stud. 21(3):100-106.